NOTICE

All drawings located at the end of the document.

REMEDIAL INVESTIGATION REPORT FOR HIGH PRIORITY SITES (881 HILLSIDE AREA)

VOLUME I
(REPORT TEXT AND PLATES)

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS PLANT
GOLDEN,COLORADO
JULY 1, 1987

ROCKWELL INTERNATIONAL
NORTH AMERICAN SPACE OPERATIONS
ROCKY FLATS PLANT

UNITED STATES DEPARTMENT OF ENERGY
ADMINISTRATION CONTRACT DE-AC04-76DP03533

TABLE OF CONTENTS

TABLE OF CONTENTS
(CONTINUED)

TABLE OF CONTENTS
(CONTINUED)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

APPENDICES

LIST OF PLATES

APPENDICES

TABLE 8-1
WELLS WITHIN TWO MILES OF
THE 881 HILLSIDE AREA,
PLUS THE NEAREST DOWNGRADIENT WELLS

PERMIT NUMBER	LOCATION				USE	WELL DEPTH (feet)	WATER LEVEL (feet)	YIELD (gpm)	OWNER	DATE WELL CONSTRUCTED
	QUARTER	SEC.	TSP.	RNG.						
119287	SW/NW	31	T.1S	R.69W	1	Unk	Unk	Unk	Roberts, B.A.	4/22/81
105613A	NE/NW	31	T.1S	R.69W	1	Unk	Unk	Unk	Hart, G.D.	6/22/79
108871	NW/NW	31	T.1S	R.69W	1	Unk	Unk	Unk	Smith, M.R.	7/23/79
105681	NE/NE	32	T.1S	R.69W	0	Unk	Unk	Unk	Fuentes, J.J.	4/18/79
106022A	NW/NW	32	T.1S	R.69W	1	Unk	Unk	Unk	Kingsburg, D.	5/4/79
121149	NW/NW	32	T.1S	R.69W	1	Unk	Unk	Unk	Kois, R.W.	7/28/81
104756	NE/NE	19	T.2S	R.69W	0	Unk	Unk	Unk	Welt, D.L.	4/8/81
26942F	NE/NW	19	T.2S	R.69W	8	Unk	Unk	Unk	Cook, M.E.	11/8/84
139972	SE/SE	19	T.2S	R.69W	3	Unk	Unk	Unk	Coleman, J.R.	6/17/85
131841	NE/NW	19	T.2S	R.69W	6	Unk	Unk	Unk	Cook, M.E.	8/2/83
26937F	NW/NW	19	T.2S	R.69W	8	Unk	Unk	Unk	Cook, M.E.	11/3/84
26	NE/NE	19	T.2S	R.69W	1	66	27	15	Ladwig, A.E.	6/27/57
223	SW/SE	19	T.2S	R.69W	1	110	10	6	Schofield, James & Betty	8/28/57

EXECUTIVE SUMMARY

This report presents the results of the remedial investigation of the high priority sites at the Rocky Flats Plant, Golden, Colorado. The objectives of the remedial investigation are to verify the existence and location of the waste disposal sites in the general vicinity of the 881 Hillside Area, to characterize the sites, to evaluate the nature and extent of contamination, and to develop data needed for feasibility studies of remedial alternatives as appropriate.

The Rocky Flats Plant is a Department of Energy (DOE) facility manufacturing components for nuclear weapons and has been in operation since 1951. The Plant fabricates components from plutonium, uranium, beryllium, and stainless steel. Production activities include metal fabrication, machining and assembly. Both radioactive and nonradioactive wastes are generated in the process. Current waste handling practices involve on-site and off-site recycling of hazardous materials and off-site disposal of solid radioactive materials at another DOE facility. In the past, both storage and disposal of hazardous and radioactive wastes occurred at on-site locations. Preliminary assessments under the DOE Comprehensive Environmental Assessment and Response Program (CEARP) identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

CEARP investigations at Rocky Flats Plant have been integrated with other RCRA and CERCLA issues pursuant to the Compliance Agreement signed by representatives of the DOE, the U.S. Environmental Protection Agency (EPA) and the State of Colorado (Colorado Department of Health) on July 31, 1986. The Compliance Agreement addresses hazardous and radioactive mixed waste management at Rocky Flats Plant. The

CEARP Phase 1 Installation Assessment for Rocky Flats Plant included analyses of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. CEARP Phase 1 identified approximately 70 sites or groupings of sites that could potentially have adverse impacts on the environment. Data collected during preparation of the RCRA Part B Operating Permit Application identified several additional potential sites. All of these potential sites at Rocky Flats Plant were designated as solid waste management units (SWMUs), and assigned a reference number.

Hydrogeological and hydrogeochemical characterization on an installation-wide basis was performed at Rocky Flats in 1986 as part of the preparation of the Plant RCRA Part B Permit Application. Analysis of these data has identified four areas which are the most probable sources of environmental contamination, with each area containing several sites. These areas are the 881 Hillside, the 903 Pad Area, the Mound Area, and the East Trenches Area. The ten sites (SWMUs) comprising the 881 Hillside Area were investigated as the high priority sites because of the concentrations of volatile organic compounds present in the ground water and their proximity to one of the surface drainages from the Plant.

The 881 Hillside remedial investigation began in March 1987. The investigation consisted of the preparation of detailed topographic maps, radiometric and organic vapor screening surveys, surface geophysical surveys, a soil gas survey, a boring and well completion program, soil sampling, and ground and surface water sampling.

Results of the remedial investigation show that no further action is required for four (SWMUs 102, 105, 145, 177) of the ten sites on the 881 Hillside. The six sites which require further characterization are:

1) SWMU 103 - organic liquid disposal area south of the 881 Building;

2) SWMU 104 - organic liquid disposal area along the road east of the 881 Building;

3) SWMU 106 - cooling tower overflow cleanout pipe;

4) SWMU 107 - potentially contaminated soil and surface water in the vicinity of a building footing drain;

5) SWMU 119 - two solvent and lathe coolant storage areas on the hillside east of Building 881 and above the perimeter road; and

6) SWMU 130 - plutonium contaminated soil disposal area located east of the 881 Building and downslope from SWMU 104.

At this time, quality assurance/quality control data compilation and review is incomplete. Therefore, the data reported and corresponding discussions in this draft report are subject to re-interpretation.

Ground water occurs in both soil and bedrock materials beneath all of the SWMUs. Flow is mostly to the south toward Woman Creek in the sandy clays and gravels of the colluvium mantling the slope. Some flow also occurs from the colluvium into the Arapahoe Formation bedrock under the strong downward gradient between the colluvium and the bedrock; however, most of the hillside is underlain by low permeability claystone. The colluvium is recharged by flow from the Rocky Flats Alluvium and possibly by flow from more permeable bedrock units in the more elevated portions of the hillside. The ground water is contaminated with volatile organic compounds downgradient of building 881 and SWMU 119. Ground water at the 881 Hillside also shows slightly elevated levels of some radionuclides relative to samples taken west of the Plant (background). Strontium concentrations are also elevated above

background. Further investigation is required to determine if the SWMUs on the 881 Hillside are contributing to the elevated levels of radionuclides and strontium. Because of retardation processes or limited ground-water flow, neither strontium or volatile organic compounds are detectable downgradient in the valley fill alluvium along Woman Creek. Elevated radionuclide concentrations were reported for one well in the valley fill alluvium of Woman Creek; however, current and historical data for wells downgradient of this point do not show radionuclide contamination.

Surface water traverses the hillside as sheet runoff and channelized flow from developed areas. In addition, the hillside is crossed by the South Interceptor Ditch, a ditch designed to divert runoff from the Plant around Woman Creek. Woman Creek flows in the drainage south of the hillside. All SWMUs are well out of the 100 year floodplain. Based on stream flow and surface water quality sampling, it appears that volatile organic compounds originating from the 881 Hillside are entering the Interceptor Ditch. Additionally, sites on the 881 Hillside may be contributing some radionuclide contamination to the surface water system. Further characterization of the 881 Hillside sites is necessary to identify which, if any, SWMUs are a source of radioactive contamination. Regardless of the source, radionuclide levels are at or near upstream (background) levels in Ponds C-1 and C-2 located downstream of the 881 Hillside. The elevated radionuclide concentrations are at least ten times lower than the proposed EPA drinking water standards (EPA, 1986).

Ambient air monitoring for radionuclides and Criteria Pollutants (total suspended particulates, ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide and lead) during the past 10 years and during the investigation indicate that air quality is not degraded by operations at the Plant. In addition, an ambient air survey during the remedial investigation did not detect any volatile organics emanating from the hillside.

Biota at the Plant have been identified, classified, and studied with respect to plutonium uptake. No endangered species exist at the Plant, and no population-level effects due to plutonium were found.

Because of Plant security practices, the closest members of the public to the 881 Hillside are at least 1.6 miles from the area. Currently, the closest residence is 2.1 miles from the center of the 881 Hillside. Neither ground water, surface water, nor air has carried contaminants from the 881 Hillside to the property boundary. Therefore, there is not an immediate public health threat. A risk assessment is needed to evaluate the potential for long-term impacts.

1.0 INTRODUCTION

A comprehensive, phased program of site characterization, remedial investigations, feasibility studies, and remedial/corrective actions is in progress at the Rocky Flats Plant. These investigations are pursuant to the U.S. Department of Energy (DOE) Comprehensive Environmental Assessment and Response Program (CEARP) and a Compliance Agreement finalized by representatives of DOE, the U.S. Environmental Protection Agency (EPA) and the State of Colorado (CDH) on July 31, 1986. The Agreement addresses hazardous and radioactive mixed waste management at the Rocky Flats Plant. The program developed by DOE, EPA and CDH in response to the Agreement addresses RCRA and CERCLA issues and has been integrated with CEARP investigations.

CEARP is being implemented in five phases. CEARP Phase 1 (Installation Assessment) has already been completed at Rocky Flats Plant. CEARP Phase 1 evaluated present compliance with environmental laws and ascertained the magnitude of potential environmental concerns. CEARP Phase 2 (Monitoring Plans and Remedial Investigations) will complete the environmental evaluation of potential environmental concerns identified in CEARP Phase 1, and plan and carry out sampling programs, as required, to understand potential contaminant sources and environmental pathways. CEARP Phase 3 (Feasibility Studies) will develop remedial action plans to mitigate environmental problems identified as needing correction in CEARP Phase 2. CEARP Phase 4 (Remedial/Corrective Action) will implement recommended site-specific remedial actions identified in CEARP Phase 3. CEARP Phase 5 (Compliance and Verification) will verify and document the adequacy of remedial actions carried out

under CEARP Phase 4 and identify and plan for any continuing monitoring requirements.

CEARP Phase 2 consists of CEARP Phase 2a, Monitoring Plans, and CEARP Phase 2b, Site Characterizations (Remedial Investigations). CEARP uses a three-tiered approach in preparing monitoring plans: the CEARP Generic Monitoring Plan (DOE, 1986a), the Installation Generic Monitoring Plan/Comprehensive Source and Plume Characterization Plan (DOE, 1987a), and the Site Specific Monitoring Plans (SSMPs). The Monitoring Plan typically consists of five parts: Synopsis, Sampling Plan, Technical Data Management Plan, Health and Safety Plan, and Quality Assurance/Quality Control Plan.

A site specific monitoring plan was submitted to EPA and CDH in February 1987 (DOE, 1987b). The plan serves as the Work Plan for Remedial Investigations for high-priority sites at the Rocky Flats Plant.

1.1 OBJECTIVES AND SCOPE

This report describes the results of the remedial investigation of the high priority sites at Rocky Flats Plant. The objectives of the investigation are to verify the existence and locations of suspected contaminant sources on the hillside in the general vicinity of Building 881, to characterize the contents of the sites, to evaluate the nature and extent of any contamination emanating from the sites, and to develop sufficient information to support a feasibility study of alternatives for remedial/corrective action.

The report describes the nature of the various contaminant sources on the 881 Hillside and then describes the three major pathways for contaminant transport (ground water, surface water and air). Flora and fauna in the general vicinity of the

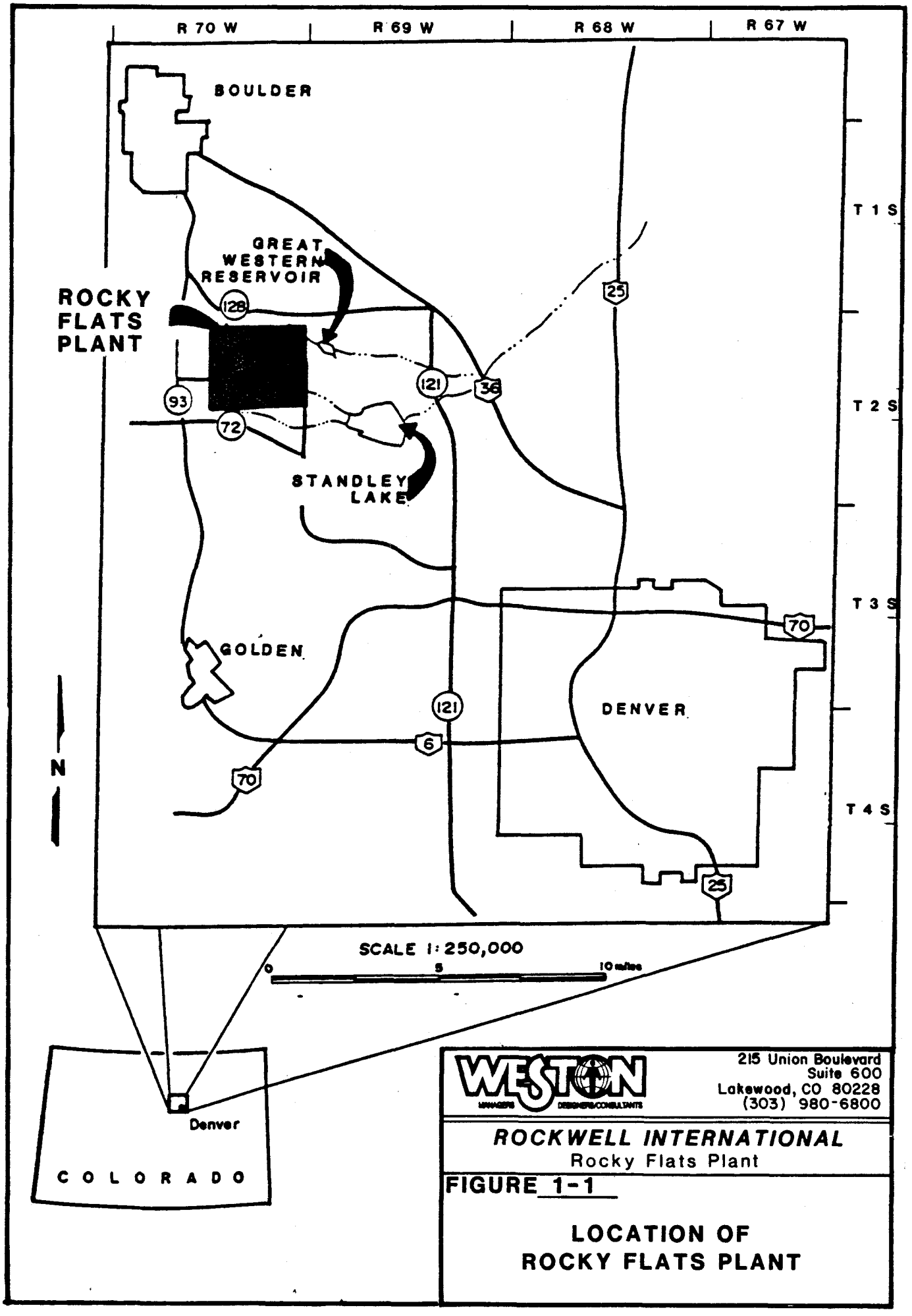
Plant are discussed. The report closes with an evaluation of public health and environmental concerns. The format of the report follows EPA guidance for remedial investigations (EPA, 1985). Data are included from monitoring programs conducted as early as 1974, although most of the emphasis is placed on data developed during and after 1986. All data used in the report are presented in appendices to the main text.

1.2 SITE BACKGROUND INFORMATION

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 1-1). The site consists of approximately 6550 acres of federally owned land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th principal meridian. Major buildings are located within the Plant security area of approximately 400 acres. The security area is surrounded by a buffer zone of approximately 6150 acres.

The Rocky Flats Plant is a government-owned, contractor-operated (GOCO) facility. It is part of a nation-wide nuclear weapons research, development, and production complex administered by the Albuquerque Operations Office of the U.S. Department of Energy. The operating contractor for the Rocky Flats Plant is Rockwell International.

The Plant is a key DOE facility that produces components for nuclear weapons; therefore, its product is directly related to national defense. The Plant fabricates components from plutonium, uranium, beryllium, and stainless steel. Production activities include metal fabrication and assembly, chemical recovery and purification of process-produced transuranic radionuclides, and related quality control functions. Research and engineering programs supporting these activities involve chemistry, physics, materials technology, nuclear safety, and mechanical engineering.



WESTON
MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 1-1

LOCATION OF ROCKY FLATS PLANT

Approximately 130 structures on the Plant site contain approximately 2.63 million square feet of floor space. Of this space, major manufacturing, chemical processing, plutonium recovery, and waste treatment facilities occupy about 1.65 million square feet, and major laboratory and research buildings occupy about 170,000 square feet. The remaining floor space (814,000 square feet) is divided among administrative, utility, security, warehouse, storage and construction contractor facilities.

The Rocky Flats Plant was constructed in 1951 and limited operations began in 1952 under the direction of the Atomic Energy Commission. In 1975, responsibility for the Plant was assigned to the Energy Research and Development Administration, which was succeeded by DOE in 1977. Dow Chemical Company was the prime operating contractor at the facility from 1951 until 1975, when Rockwell International was awarded the operating contract.

1.3 NATURE AND EXTENT OF PROBLEM

This section provides a brief overview of the past environmental monitoring and characterization activities performed at Rocky Flats Plant, and establishes the foundation for the remedial investigation.

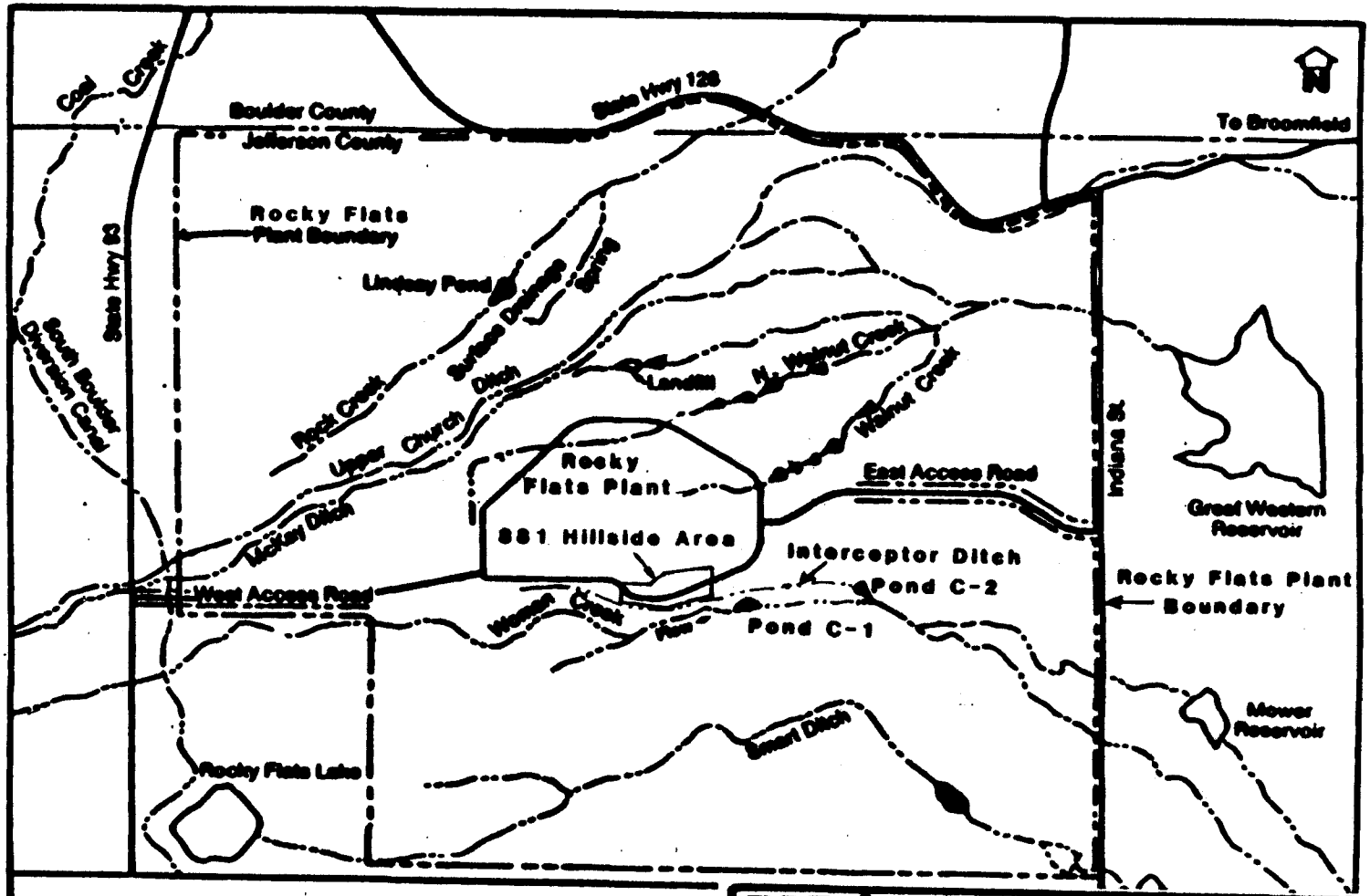
The CEARP Phase 1 Installation Assessment for Rocky Flats Plant (DOE, 1986b) included analyses of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. CEARP Phase 1 identified approximately 70 sites or groupings of sites that could potentially have adverse impacts on the environment. Additional data collected during preparation of the RCRA Part B Operating Permit Application identified several additional potential sites.

A list of solid waste management units is presented in Appendix 1 of the RCRA Part B Operating Permit Application [3004(u) Solid Waste Management Units] (Rockwell Internationa, 1986a). These solid waste management units are divided into three categories. The first category includes those hazardous waste management units which will continue to operate and which require a RCRA Operating Permit. The second category includes those hazardous waste management units that are being closed under RCRA Interim Status. The third category includes those inactive waste management units (RCRA continuing release sites) that are identified under Section 3004(u) of RCRA. Another class of sites is regulated under CERCLA. Thsee CERCLA areas contain only radioactive wastes. However, for ease in referencing these units and/or areas, they have been collectively termed Solid Waste Management Units. A base map and a tabulation of all solid waste management units cross-referenced to the CEARP Phase 1 report is contained within the IGMP/CSPCP Monitoring Plan for Rocky Flats Plant (DOE, 1987a).

Potential contaminant source areas were evaluated and prioritized based on preliminary investigations (DOE, 1986a; Rockwell International, 1986a and 1986b). Three of the potential contaminant source areas are being closed under RCRA: the solar ponds, the west spray field, and the present landfill (Rockwell International, 1986c). Four other areas are currently under investigation using the remedial investigation approach detailed in DOE (1987a and 1987b). These areas are:

1) 881 Hillside,
2) 903 Pad Area,
3) Mound Area, and
4) East Trenches.

As discussed earlier, this report deals with the investigation of the 881 Hillside Area (Figure 1-2).



WESTON
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 1-2

Location of 881 Hillside Area

Not to Scale

The ten past waste disposal sites located in the 881 Hillside Area are designated as high priority sites for remedial investigations for the following reasons (DOE, 1987c):

1) The highest concentrations of volatile organic compounds at any area of the Plant site occur at the 881 Hillside;

2) Permeable soils favorable to contaminant transport exist in the 881 Hillside area; and,

3) The 881 Hillside is close to a surface drainage (Woman Creek) leading off-site.

Historic waste disposal practices appear to have contributed to ground-water contamination in the 881 Hillside Area. These practices included oil sludge disposal, chemical burial, fuel oil leaks, liquid dumping, drum disposal, and various chemical spills. Waste disposal at 881 Hillside sites is described in detail in Section 3.0. Ground-water contamination is characterized by the presence of volatile organic compounds in isolated areas of the hillside. Ground-water conditions are discussed in detail in Section 4.0.

1.4 PREVIOUS INVESTIGATIONS

A series of investigations have been conducted at the Plant. These programs include:

1) Several drilling programs beginning in 1961 that resulted in approximately 60 wells by 1985;

2) An investigation of surface and ground water by the U.S. Geological Survey (Hurr, 1976);

3) An integrative report on ground-water hydrology using all data from 1961 to 1985 (Hydro-Search, Inc. 1985);

4) A preliminary electromagnetic survey of the perimeter of the Plant (Hydro-Search, Inc., 1986);

5) A soil gas survey of the plant perimeter and buffer zone (Tracer Research, Inc., 1986);

6) A detailed drilling and sampling program involving the construction of approximately 70 wells, surface-water monitoring and sampling, and sediment sampling (Rockwell International, 1986a, 1986d, and 1986e);

7) A review of historical waste disposal practices and prioritization of disposal sites based on reported waste disposal practices and on ground-water quality, geophysical, and soil gas data (Rockwell International, 1986b and DOE, 1986b); and

8) Environmental monitoring programs addressing air, surface water, ground water, and soils (Rockwell International, 1975-1986).

1.4.1 Air Pathway

The air pathway has been adequately documented by studies performed at the Plant (DOE, 1986b and Rockwell International, 1986f). Additional air pathway characterization is not anticipated under CEARP. However, an organic vapor screening survey and air sampling for worker health and safety was performed as part of remedial investigation activities.

1.4.2 Surface Water Pathway

Considerable work has been done at Rocky Flats Plant on characterizating surface water and sediment chemistry (Hurr, 1976; Rockwell International, 1986a and 1986c). Site specific surface water information was collected during the remedial investigations described in the Work Plan (DOE, 1987b).

1.4.3 Ground-water Pathway

Geologic information was collected prior to plant construction in the early 1950s, and the ground-water pathway has been monitored since 1960. An intensive ground-water investigation was performed in 1986 that involved the installation of approximately 70 new wells to monitor both alluvial and bedrock ground water (Rockwell International, 1986a). This work, coupled with earlier investigations (e.g., Hurr, 1976 and HydroSearch, Inc., 1985), has characterized the plant-wide hydrogeology and the site-specific hydrogeology of the solar evaporation ponds. The results of

the work under the initial site characterization are summarized in the Work Plan (DOE, 1987b). Additional ground-water pathway information was collected during the remedial investigation as outlined in the Work Plan (DOE, 1987b).

1.5 REMEDIAL INVESTIGATION SUMMARY

The remedial investigation of the 881 Hillside began in March 1987 following plans presented in DOE (1987a and 1987b). The investigation consists of:

1) Preparation of detailed topographic maps;

2) Radiometric and organic vapor screening surveys;

3) Geophysical surveys using electromagnetics, resistivity, magnetometry, and metal detection;

4) Soil gas sampling;

5) Well drilling and installation program involving 17 borings and 7 completed wells;

6) Hydraulic testing program consisting of packer and/or drawdown-recovery tests on every new well;

7) Ground-water sampling and analysis program involving sampling of all 1986 and 1987 wells in the study area, as well as sampling of earlier wells that had shown contamination in the past;

8) Surface water sampling program involving sampling of surface water stations along Woman Creek and the South Interceptor Ditch, plus two ponds, two outfalls and a seep; and,

9) Soil boring, sampling and analysis program involving 17 borings and submission of samples from within, above, and below suspected wastes.

1.6 OVERVIEW OF REPORT

This report describes the results of the 881 Hillside remedial investigation. It begins with a description of the regional setting and site features. Then, information on location, geometry, and characteristics of the waste sites is presented. After characterizing the sources, the three pathways are described, together with a description of any contamination. First, the geology and ground-water hydrology of the hillside

are described in detail, together with the nature and extent of soil and ground-water contamination. Second, the surface-water system and quality of the Woman Creek drainage are described. Finally, the air pathway is described and the results of extensive air monitoring are discussed. The report closes with descriptions of flora and fauna in the vicinity of the plant and a discussion of public health and environmental concerns.

Detailed descriptions of the investigations are provided in appendices (geophysics, soil gas, and drilling). Data used in the evaluations are also presented in separate appendices (analytical chemistry results, hydrogeologic data and air data). In addition, an appendix is provided for quality assurance/quality control data.

2.0 REGIONAL SETTING AND SITE FEATURES

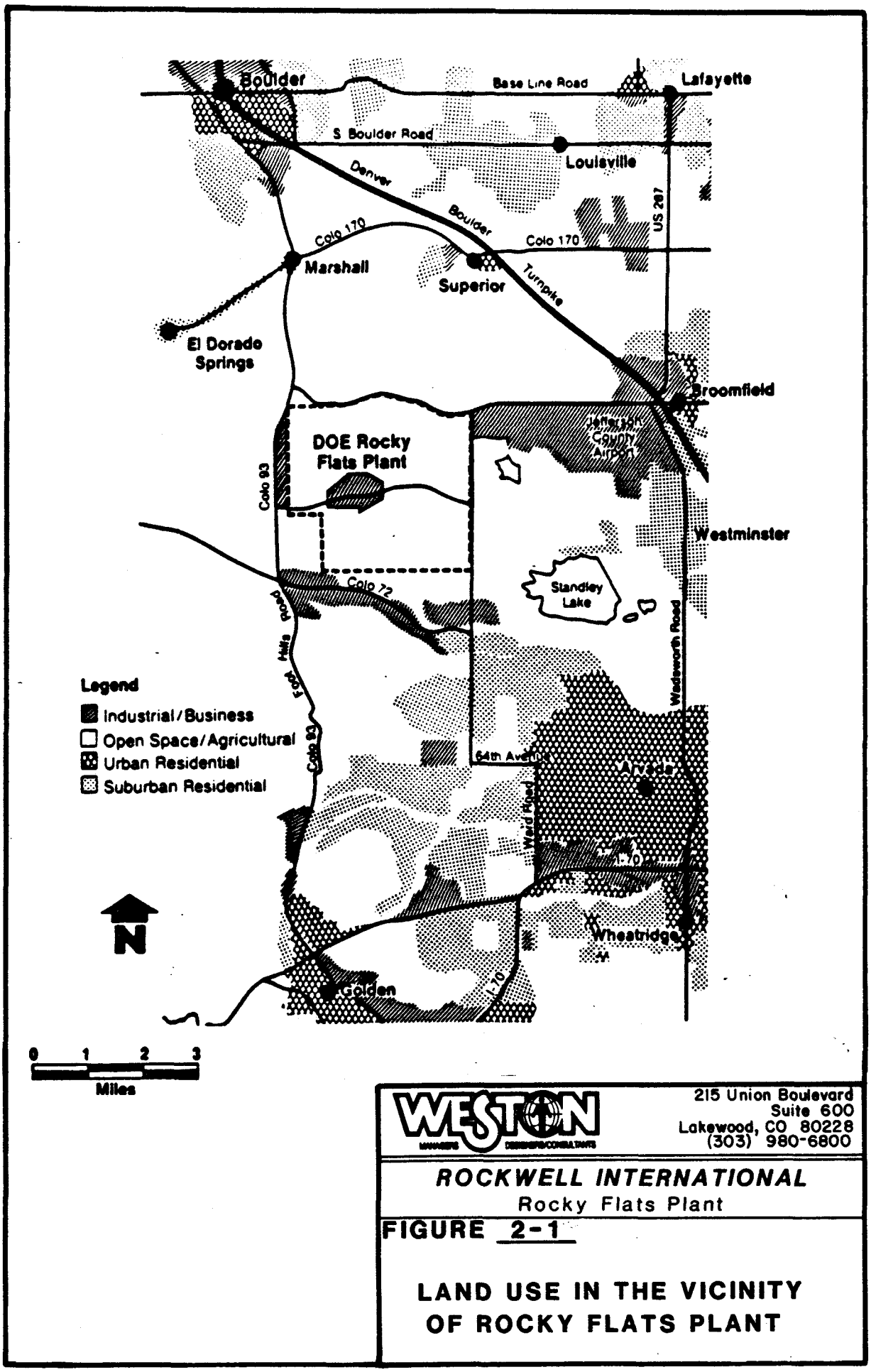
2.1 DEMOGRAPHY

Approximately 50 percent of the area within 10 miles of the Plant is in Jefferson County. The remainder is located in Boulder County (40 percent) and Adams County (10 percent). According to the 1973 Colorado Land Use Map, 75 percent of this land was unused or was used for agriculture. Since that time, portions of this land have been converted to housing, and today, several new housing subdivisions are being started within a few miles of the buffer zone. One of the subdivisons is located south of the Jefferson County Airport and several are located southeast of the Plant.

A demographic study using 1980 census data (Setlock and Barker, 1985) shows that approximately 1.8 million people lived within 50 miles of the Plant in 1980. This was projected to increase to 3.5 million people by the year 2000. Approximately 9,500 people lived within 5 miles of the Plant in 1980, with a projected increase to 20,000 people by the year 2000. The most populous sector was to the southeast, toward the center of Denver. This sector had a 1980 population of about 555,000 people living between 10 and 50 miles from the Plant, with a projected increase to 1.5 million by the year 2000.

2.2 LAND USE

The Rocky Flats Plant is located in a basically rural area (Figure 2-1). There are no public facilities or institutions such as schools, prisons, or hospitals within five miles of the Plant. The nearest educational facility is the Sierra Elementary School, which is six miles southeast of the Plant. Other schools are located in the same



WESTON MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 2-1

LAND USE IN THE VICINITY OF ROCKY FLATS PLANT

general area, but somewhat farther from the Plant. The closest hospital to the Plant is Boulder Memorial Hospital, 10 miles northwest.

Some of the land adjacent to the Plant is zoned for industrial development. Industrial facilities within 5 miles of the Plant include the TOSCO laboratory (40 acre site located 2 miles south), the Great Western Inorganics plant (2 miles south), the Frontier Forest Products yard (2 miles south), the Idealite lightweight aggregate plant (2.4 miles northwest), and the Jeffco Airport and Industrial Park (990 acre site located 4.8 miles northeast).

Several ranches are located within 10 miles of the Plant, primarily in Jefferson and Boulder Counties. They are operated to produce crops, raise beef cattle, supply milk, and breed and train horses. According to the 1977 Colorado Agricultural Statistics, 14,000 acres of crops were planted in 1976 in Jefferson County (total land area of approximately 475,000 acres) and 56,200 acres of crops were planted in Boulder County (total land area of 405,760 acres). Crops consisted of winter wheat, corn, barley, dry beans, sugar beets, hay, and oats. Livestock consisted of 9,500 head of cattle, 200 pigs, and 400 sheep in Jefferson County and 34,000 head of cattle, 2,300 pigs, and 6,500 sheep in Boulder County.

The closest park and recreational area is the Standley Lake area, which is approximately 5 miles from the Plant site. Boating, picnicking, and limited overnight camping are permitted. Several other small parks are present in communities within 10 miles of the Plant. The closest major park, Golden Gate Canyon State Park, is located approximately 15 miles to the southwest, provides 8,400 acres of general camping and outdoor recreation. Other national and state parks are located in the mountains west of the Plant, but all are more than fifteen miles away.

2.3 NATURAL RESOURCES

Mineral resources in the vicinity of the Plant include sand, gravel, crushed rock, clay, coal, and uranium (Van Horn, 1972). Each of these is described below.

There are extensive deposits of sand and gravel in the Rocky Flats area. The Rocky Flats Alluvium has been a source of sand and gravel at the Plant. Van Horn (1972) estimates that there are approximately 250 million cubic yards of sand and gravel suitable for concrete and mineral aggregate in the Golden Quadrangle. The nearest sand and gravel mine currently operating is located about one mile southwest of the Plant.

Several quarries have extracted rock from the Precambrian metamorphics and the Tertiary igneous rock exposed in the Golden Quadrangle. Both materials have been used for concrete aggregate and riprap. At the present time, rock is being quarried from the Ralston Dike (about four miles southwest of the Plant) for use as riprap, concrete aggregate, and road material.

Clay has been mined from both the Laramie Formation and the Pierre Shale (west of the Plant) from Coal Creek south to Golden. Three pits in clay and claystone beds of the steeply dipping lower part of the Laramie Formation are presently being mined. The clay produced is best suited for brick, tile, and sewer pipe. Clay from the upper part of the Pierre Shale was mined and treated to form a lightweight aggregate at the facility operated by the Idealite Cement Company near the northwest corner of the site. The Idealite operation closed in 1976.

Sub-bituminous coal occurs in several lenticular bodies in the lower part of the Laramie Formation (west of the Plant). No coal has been mined in the area since 1950. An estimated 10 million tons of coal has been removed from 13 mines in the

Golden Quadrangle south of the Plant. Assuming an average thickness of 6 feet of mineable coal, 250 million tons of coal still lie within 1,000 feet of the surface. Spencer (1961) estimates the total coal production from the Louisville Quadrangle north of the Plant was 20 million tons and that few sizable areas remain where coal is of sufficient thickness and quality to justify mining.

Uranium is currently being mined at the Schwartzwalder uranium mine, about four miles southwest of the Plant. The mine has been the largest producer of vein-type uranium ore in Colorado and ranks among the six largest of this type in the United States. Ore shipments have yielded more than 11.5 million pounds of uranium. Unmined reserves are believed to be sufficient to supply 600 tons of ore per day for the next 10 years.

2.4 CLIMATOLOGY

The area surrounding the Rocky Flats Plant has a semiarid climate typical of much of the Rocky Mountain region. Temperatures are moderate; extremely warm or cold weather is usually of short duration. On the average, daily summer temperatures range from 55 to 85 degrees F and winter temperatures range from 20 to 45 degrees F. Low average relative humidity (46 percent) produced by the blocking effect of the mountains results in a very comfortable climate (DOE, 1980).

The average annual precipitation is 15 inches. Approximately 40 percent of the precipitation falls during the spring season, much of it as snow. Thunderstorms from June to August account for an additional 30 percent. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, generally occurring between October and May (DOE, 1980).

The area experiences Chinook winds with gusts occasionally exceeding 100 miles per hour because of its location 4 miles east of the Front Range. Atmospheric drainage flows come down off the mountains and move to the north and northeast along the South Platte River Valley (Crow, 1974). These drainage flows generally occur at night and are under stable atmospheric dispersion conditions when atmospheric mixing is limited (worst case for releases to the atmosphere).

2.5 PHYSIOGRAPHY

The Rocky Flats Plant is located at an elevation of approximately 6,000 feet above mean sea level. The site is on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province (Fenneman, 1931). The Colorado Piedmont ranges in elevation from 4,000 feet on the east to 7,000 feet on the west. The Piedmont merges to the east with the High Plains section of the Great Plains Province and is terminated abruptly on the west by the Front Range section of the Southern Rocky Mountain Province.

The Colorado Piedmont is an area of dissected topography and denudation where Tertiary strata underlying the High Plains have been almost completely removed. In a regional context, the piedmont represents an old erosional surface along the eastern margin of the Rocky Mountains. It is underlain by gently dipping sedimentary rocks (Paleozoic to Cenozoic in age), which are abruptly upturned at the Front Range to form hogback ridges parallel to the mountain front. The piedmont surface is broadly rolling and slopes gently to the east with a topographic relief of only several hundred feet. This relief is due both to resistant bedrock units that locally rise above the surrounding landscape and to the presence of incised stream valleys. Major stream valleys which transect the piedmont from west to east have their origin in the Front Range. Small local valleys have developed as tributaries to

these major streams within the piedmont. In the area of the Plant, a series of Quaternary pediments have been eroded across this gently rolling surface.

The eastern margin of the Front Range a few miles west of the Plant is characterized by a narrow zone of hogback ridges and flatirons formed by steeply east-dipping Mesozoic strata (such as the Dakota Sandstone and the Fountain Formation). Less resistant sedimentary units were removed by erosion. The Front Range reaches elevations of 12,000 to 14,000 feet above mean sea level 15 miles farther west. The range itself is broad and underlain by resistant gneiss, schist and granitic rocks of Precambrian age. The resistant nature of these rocks has restricted stream erosion so that deep, narrow canyons have developed in the Front Range.

Several terraces and pediments have been eroded across both hard and soft bedrock in the area of the Plant during Quaternary time (Scott, 1963). The Rocky Flats pediment is the most extensive of these, forming a broad flat surface north of Coal Creek. The broad pediments and more narrow terraces are covered by thin alluvial deposits of ancient streams draining eastward into the Great Plains. The sequence of pediments reflects repetitive physical processes associated with cyclic changes in climate. Each erosional surface and stratigraphic sequence deposited on it probably represents a single glacial cycle. The oldest and highest pediment, the Subsummit Surface (Scott, 1960), truncates the hogback ridges of the Front Range. Three successively younger pediments, veneered by alluvial gravels, extend eastward from the mountain front. Erosion of valleys into the pediments followed each depositional cycle so that, near the mountain front, stratigraphically younger geologic units occur at topographically lower elevations as narrow terrace deposits along the streams. From oldest to youngest, the three pre-Wisconsin deposits are the Rocky Flats Alluvium, the Verdos Alluvium and the Slocum Alluvium (Scott, 1965). A series of

Wisconsin and post-Wisconsin terrace deposits are present at lower elevations along streams that have incised the older pediments (east of the Plant).

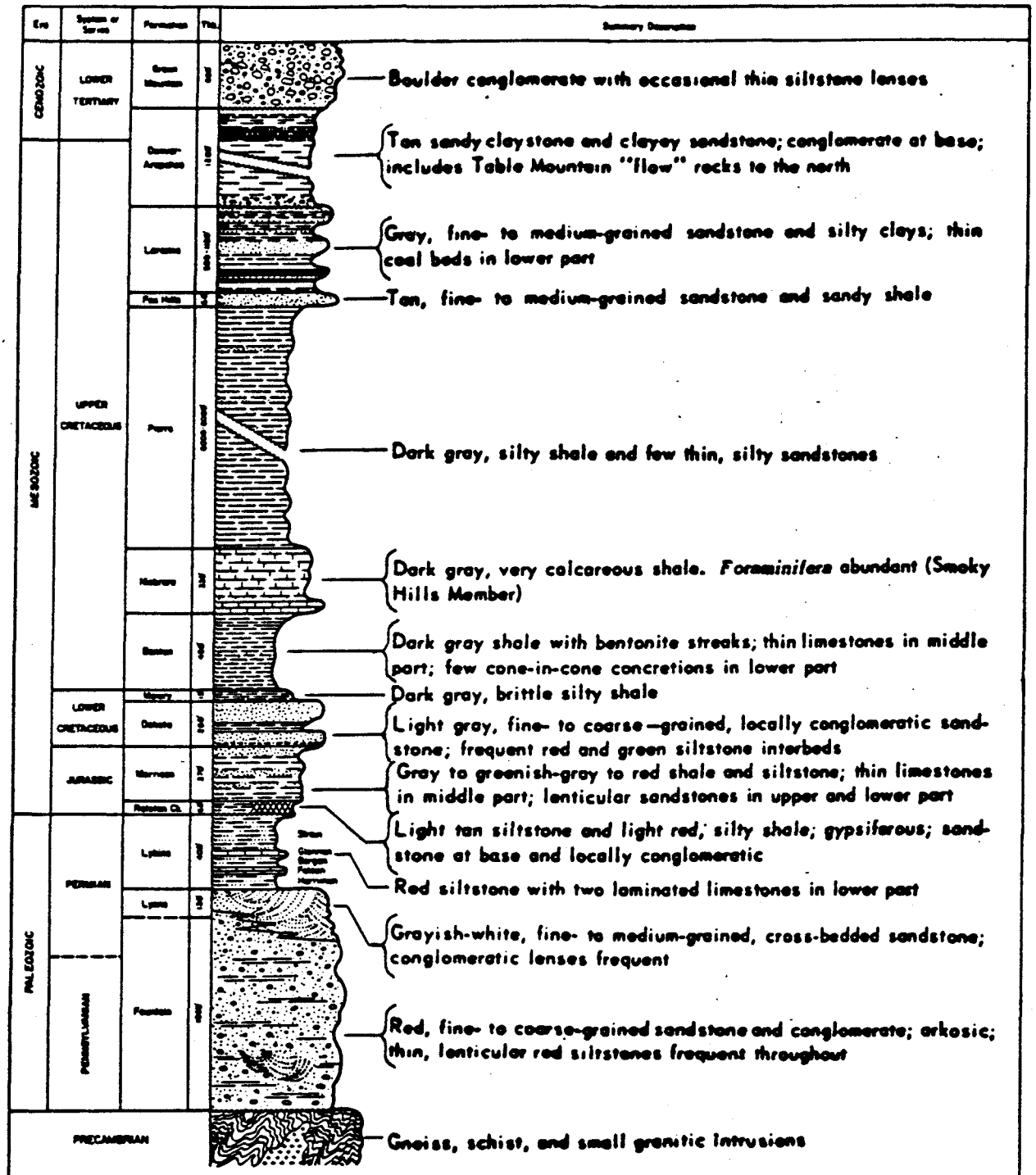
The Rocky Flats Plant is located on a relatively flat surface of Rocky Flats Alluvium. The pediment surface and overlying alluvium (generally 10 to 50 feet thick, although the alluvium is as much as 100 feet thick west of the Plant) have been eroded by Walnut Creek on the north and Woman Creek on the south so that bluffs along these streams range in height from 50 to 150 feet. The gradient of the gently eastward-sloping, dissected Rocky Flats Alluvium surface varies from 0.7 percent at the Plant to approximately 2 percent just east of the Plant.

2.6 GEOLOGY/SOILS

2.6.1 Geology

The Rocky Flats Plant is located on the northwestern flank of the Denver Basin and is underlain by about 12,000 feet (Hurr, 1976) of Paleozoic and Mesozoic sedimentary rocks. The Denver Basin is an asymmetric syncline that formed during the Late Cretaceous Laramide Orogeny. The western limb of the basin dips steeply to the east, and the eastern limb dips gently to the west.

The stratigraphic section in the vicinity of the Plant begins with the Fountain Formation (Figure 2-2), unconformably overlying the Precambrian metamorphics and steeply dipping to the east. The Fountain is overlain by various units, including the thick and relatively impermeable Upper Laramie Formation. Because of the thickness (750 to 800 feet) and low permeability of the Upper Laramie, it is considered to be the base of the hydrologic system which could be affected by Plant operations. The Upper Laramie and overlying Arapahoe Formations are described generally as follows by Hurr (1976).



WESTON MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 2-2
GENERALIZED STRATIGRPHIC COLUMN GOLDEN-MORRISON AREA
(after Leroy and Weiemer, 1971)

Upper Laramie Formation

The Upper Laramie is approximately 750 to 800 feet thick and consists of buff to dark-gray, organic-rich claystone. In many localities there are interbedded sand layers near the base.

Arapahoe Formation

The Arapahoe is a continental deposit of lenticular sand bodies interbedded with clay. Carbonaceous remains of plant material are commonly found where sand and clay are thinly interbedded. The lower half of the formation contains more sand beds than the upper half. The thickness of the Arapahoe has been reduced beneath the Plant by erosion before deposition of the Rocky Flats Alluvium and is generally less than 270 feet (well 22-74). The thickness of the Arapahoe elsewhere in the basin where overlain by the Denver Formation ranges from 270 to 445 feet.

Sand bodies in the Arapahoe rarely exceed 5 to 8 feet thick. The lateral extent of the sands may be hundreds of feet, but tens of feet are more common. In many localities, the same stratigraphic horizon contains several sand bodies which are not laterally connected.

The general geologic structure of the area is north-striking beds with dips to the east. Dips are quite steep west of the Plant, on the order of 50 degrees or greater. However, because the axis of the monocline onto the Front Range appears to be inclined to the east, dips become rapidly more gentle, on the order of 7 to 15 degrees beneath the Plant itself. A major bounding fault between the Front Range and the Denver Basin, the Golden Fault, runs north-south several miles west of the Plant (at the mountain front). Although Hurr (1976) shows an extension of the Eggleston Fault

running east of the Plant, further investigation of the feature revealed that it is probably a penecontemporaneous growth fault (Dames & Moore, 1981).

2.6.2 Soils

There are six distinct unconsolidated units in the vicinity of the Plant: the Rocky Flats Alluvium, the Verdos Alluvium, the Slocum Alluvium, Terrace Alluvium, Valley Fill and Colluvium. The following descriptions of the soil units are taken from Hurr (1976).

The Rocky Flats Alluvium unconformably overlies the Laramie and Arapahoe Formations in the vicinity of the Plant. The deposit is a series of laterally coalescing alluvial fans deposited by streams (Hurr, 1976). The fans were deposited on an erosional surface cut into the bedrock units that has 50 feet of relief or more, including channelization around the hogbacks of the Lower Laramie. The alluvium consists of beds of clayey, sandy silt, some of which contain distinct horizons of subrounded gravel and cobbles. Locally, there are lenses of clean, moderately sorted medium to very coarse sand. The clayey, sandy silt is yellowish to light-reddish brown which gives the formation its characteristic color. Locally, calcium carbonate enrichment mottles the soil texture between 1 to 5 feet below land surface.

The Verdos Alluvium occupies a topographic position about 50 to 100 feet below the Rocky Flats Alluvium. The Verdos was deposited around the periphery of the present extent of the Rocky Flats Alluvium as fans and channel filling derived by erosion of the older alluvium. The maximum thickness is about 40 feet. The appearance and lithology is similar to the Rocky Flats Alluvium except that it tends to be whitish gray in color, rather than reddish brown, and does not contain the numerous large boulders.

The Slocum Alluvium is a gravel deposit containing much sand and silt derived from erosion of bedrock and the older gravel deposits. The formation has a maximum thickness in the vicinity of the Plant of about 20 feet, but is commonly 5 to 10 feet thick. It occupies a topographic position of about 300 feet below the Rocky Flats Alluvium.

Locally, two Wisconsin-age terraces are associated with the present drainages. The alluvium is derived from bedrock and reworking of older alluvial deposits. The thickness is seldom more than about 5 feet.

Valley fill occupies the bottom of the present valleys. The valley fill ranges from dark-brown, sandy, clayey silt to moderately sorted cobbles and small boulders. The valley fill along streams which head on the Rocky Flats Alluvium and have not yet cut through to bedrock tends to be coarse and have little or no fine material. Where the valley fill is deposited on bedrock, however, 0.5 to 2 feet of cobbly sand and gravel commonly is overlain by several feet of sandy, clayey silt. Subsequent erosion and deposition locally may have added more sand, gravel and cobbles on top of the silt, or cut through the valley fill to expose bedrock along the channel bottom.

Colluvium, produced by mass wasting, collects on the sides and at the base of hills and slopes. These deposits are poorly sorted mixtures of soil and debris from bedrock clay and sand mixed with gravel and cobbles derived from the older alluvium. The thickness of the colluvium rarely exceeds 2 to 3 feet (Hurr, 1976) but it is very widespread.

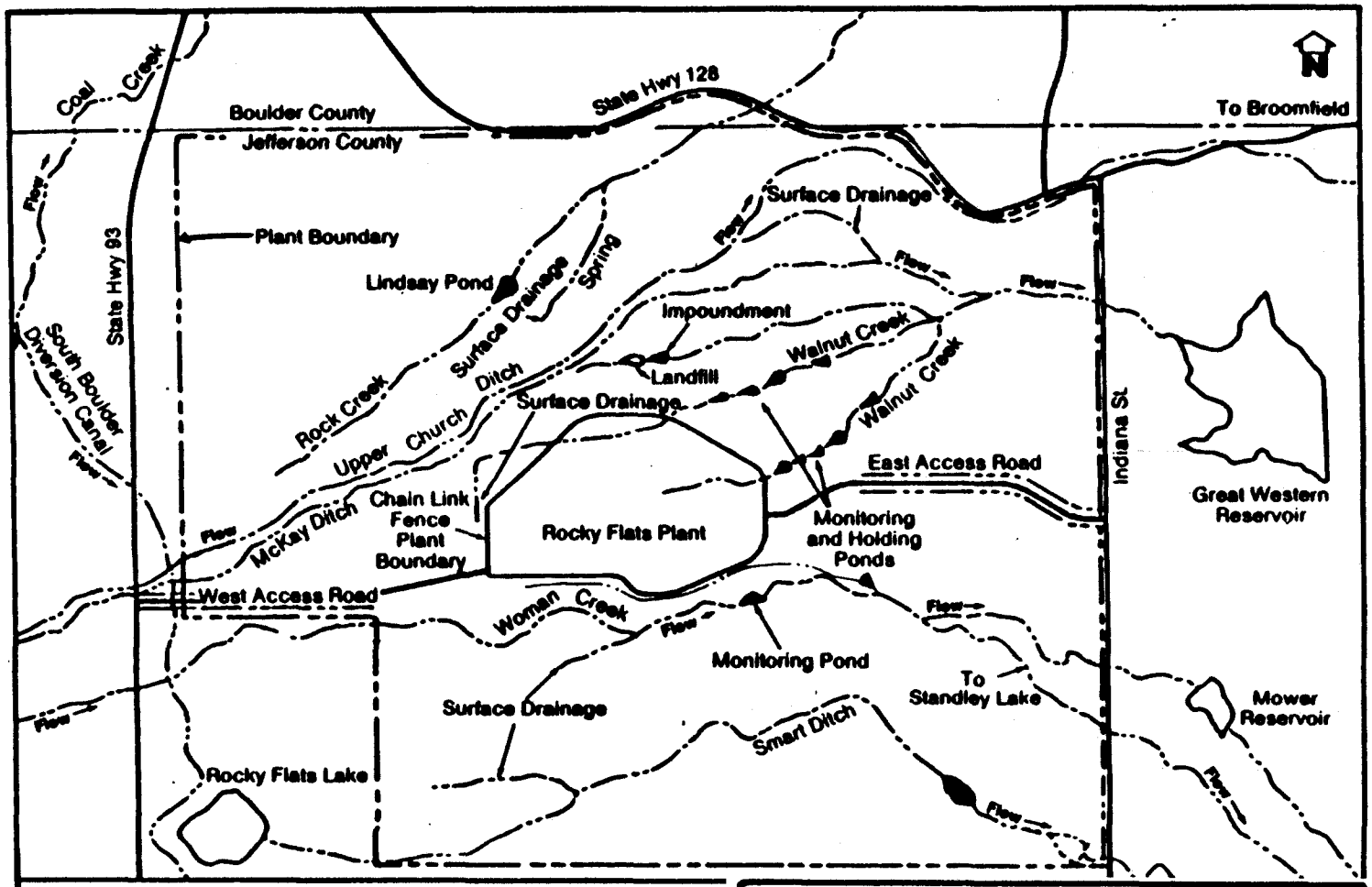
2.7 WATER RESOURCES

Surface waters in the vicinity of the Plant supply water to two reservoirs used for municipal water supply and recharge aquifers used for domestic water supply.

There are six streams in the general area (Figure 2-3): North Walnut Creek, South Walnut Creek, Woman Creek, Coal Creek, Rock Creek and Leyden Gulch. All of the streams are ephemeral, i.e. they only flow in response to precipitation events (Hurr, 1976).

In addition to the natural flows, there are six ditches in the general vicinity of the Plant. The Church, McKay, and Kinnear Ditch and Reservoir Co. Ditches (diversions of Coal Creek) cross the Plant site itself. Church Ditch delivers water to Upper Church Lake and Great Western Reservoir (City of Broomfield municipal storage). McKay Ditch also supplies water to Great Western Reservoir. Kinnear Ditch and Reservoir Co. Ditch diverts water from Coal Creek and delivers it to Standley Lake (municipal storage for the City of Westminster) via Woman Creek. Last Chance Ditch flows south of the site and delivers water to Rocky Flats Lake and Twin Lakes. Smart Ditch takes water from Rocky Flats Lake and transports it out of the area to the east. The South Boulder Diversion Canal runs along the west edge of the Plant site, diverting water from South Boulder Creek and delivering it to Ralston Reservoir (City of Denver municipal storage).

Usable ground water occurs in both the Laramie-Fox Hills and Arapahoe Aquifers. The Laramie-Fox Hills subcrops west of the Plant but has little potential for use in the general area because of its great depth (approximately 750 to 800 feet deeper than the Arapahoe). Various sands in the Arapahoe Aquifer are used for irrigation, livestock watering, and domestic purposes east of the Plant.



WESTON MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 2-3

SURFACE WATER DRAINAGE PATTERNS ROCKY FLATS PLANT

3.0 CHARACTERIZATION OF WASTE SOURCES

This section presents data from investigations of the waste disposal areas at the 881 Hillside. Waste quantities, location, components, and composition are presented. A list of hazardous substances identified above background levels at the 881 Hillside Area will also be provided along with physical and chemical data.

This discussion focuses on past waste disposal sites (SWMUs) as preliminarily identified and located in the RCRA Part B Permit Application (Rockwell International, 1986a). SWMUs are considered potential contaminant source areas and were also identified and located in the CEARP Phase I document (Rockwell International, 1986a). SWMU locations are herein revised and/or verified. Plate 3-1 presents the revised SWMU locations. As discussed in Section 1, all SWMUs have been assigned a unique identification number.

Hazardous substances expected to be present in any SWMU are based on those identified by the 1986 and 1987 field work. Soil samples are the major source of data, but soil gas samples and surface water samples are also considered. Soil samples collected in 1987 have been analyzed for the parameters listed in Table 3-1. Radionuclide results from soil samples are not yet available, and analytical data have not been received on the following soil samples: BH02870012, BH02871214, BH028718BR, BH098711CT, BH138711CT, BH148703W1, BH148706CT, BH148708W2, and BH1409BR.

The following criteria were used in the evaluation of soil samples: all parameters found below detection limits were considered not present in that sample, all parameters

TABLE 3-1

SOURCE SAMPLING PARAMETERS, SOIL AND WASTE SAMPLES

Metals

Hazardous Substance List - Metals
Beryllium
Chromium (hexavalent)
Lithium
Strontium

Organics

Hazardous Substances List - Volatiles
Oil and Grease

Radionuclides

Gross Alpha
Gross Beta
Uranium 233, 234, and 238
Americium 241
Plutonium 239
Strontium 90
Cesium 137
Tritium

Other

Characteristics (e.g., ignitability, corrosivity, reactivity)
pH

found in the blank were not considered present in field samples if found in a similar concentration (within one order of magnitude), and all parameters commonly found in soil (such as metals) were not considered to be elevated if concentrations in field samples were within one order of magnitude of the concentrations found in "background" soil samples. Background for soil samples was based on 1986 sampling and analysis done in the west buffer zone (an area not affected by any waste disposal activities). Table 3-2 presents the background soil data. Ground water and contaminant migration are discussed in Section 4.

3.1 SOLID WASTE MANAGEMENT UNIT 102

This SWMU was used in 1958 for the disposal of 30 to 50 drums of oil sludge from the cleanout of some fuel oil storage tanks. This waste was supposedly deposited in a pit and covered with soil. The location of this burial pit was based on a 1963 aerial photograph; however, other information indicated that the pit was located further to the north than indicated by the aerial photo (DOE 1986b). Soil gas results, geophysical survey results, and borings BH5-87 (placed within the probable location of SWMU 102) and BH6-87 (placed downhill and downgradient of the probable SWMU location) all found no indication of waste constituents or fill materials present in the area identified as the probable SWMU 102 unit. The only contaminant found in boreholes BH5-87 and BH6-87 above background levels was methylene chloride. This contaminant was found at BH5-87 at 38 ppb in both the 0-5 foot sample and the 8 foot sample. Likewise, this contaminant was found at BH6-87 at 42 ppb in the 10-20 foot composite sample, and at 83 ppb in the 26 foot bedrock contact sample. Methylene chloride is a common laboratory contaminant, and these levels are only slightly greater than the detection limit of approximately 20 ppb, indicating that these results are probably lab or field contamination. Had geophysical anomalies been detected or other contaminants been found in the

TABLE 3-2

CONCENTRATIONS OF METALS AND PHENOLS IN BACKGROUND SOIL

	Concentration* PPM (mg/kg)
Al	6540-9140
Sb	38 U - 41 U**
As	6.3 U - 7.0 U
Ba	125 U - 135 U
Be	3.1 U - 3.4 U
Ca	1020 - 1960
Cd	3.1 U - 3.4 U
Cr (Total)	5.6 - 13
Co	12 U - 25 U
Cu	6.6 - 10
Fe	9080 - 12,400
Pb	15 - 48
Mg	883 - 1490
Mn	196 - 337
Hg	0.1 U
Ni	13 U - 17
K	951 - 1860
Se	3.1 U - 3.4 U
Ag	3.1 U - 3.4 U
Na	63 U - 217
Tl	6.3 U - 6.8 U
Sn	25 U - 27 U
V	30 U - 38
Zn	20 - 49
Phenols	0.2 U - 0.5

* All values from West Buffer Zone in upper 12"

** "U" indicates values less than detection limits

soil or soil samples, more credence would have been given to these low levels of methylene chloride. Based on the evidence discussed above, it is believed that SWMU 102 does not exist at the expected location. Therefore, this SWMU could not be the source of environmental contamination.

3.2 SOLID WASTE MANAGEMENT UNIT 103

SWMU 103 was reportedly used for the disposal of unknown chemicals. SWMU 103 was expected to be in approximately the same location as SWMU 102, although larger in areal extent. As shown in Plate 3-1, the location of this SWMU has been revised to two separate areas based on soil gas and soil sampling analytical results. The revised locations of SWMU 103 are now to the north and west, as well as to the north and east, of the previous location.

Soil gas results to the north and west of the original SWMU 103 location indicate the presence of the volatile organic compounds tricloroethene (TCE), dichloroethene (DCE), trichloroethane (TCA), and tetrachloroethene (PCE). The results for these compounds were not isomer-specific. The majority of these contaminants have centers of concentration due west of Building 885 (Plates 3-2 through 3-5). PCE also had a center of concentration to the east of Building 885. Although no geophysical anomalies were detected at this location, geophysical surveys at the revised location of SWMU 103 are likely incapable of confirming or denying these locations, considering the nature of this SWMU.

Analytical results from soil sampling of boreholes BH1-87 and BH4-87 indicate the presence of some levels of organic contamination. Borehole BH1-87 had bis(2-ethylhexyl)phthalate present at 880 ppb in the 1 foot sample; and had bis(2-ethylhexyl)phthalate (1100 ppb), TCE (120 ppb) and PCE (190 ppb) present in the 4 foot

sample. In borehole BH4-87, Bis(2-ethylhexyl)phthalate was detected in the samples at the 9.1-10.3, 10.3-15.7, and the 19.3-20.3 foot depths at concentrations of 1600 ppb, 960 ppb, and 650 ppb, respectively. The organic compound 4-methyl-2-pentanone was also detected at a level of 68 ppb in the bedrock sample 15 feet below ground surface. The water table was encountered at a depth of 10.3 feet.

All soil gas and analytical results confirm the presence of organic contaminants in the soil at the revised SWMU 103 location.

3.3 SOLID WASTE MANAGEMENT UNIT 104

SWMU 104 was an area east of Building 881 used for disposal of unknown liquids and empty drums prior to 1969. A pit was identified in a 1965 aerial photograph with plan dimensions of 50 by 50 feet (DOE 1986b). Soil gas sampling found an isolated area of elevated TCA present in the soil gas near the general location of SWMU 104 (Plate 3-4). Geophysical results in the same area indicate variable resistivities to approximately 24 feet. These results could indicate the presence of various fill materials used to back-fill the chemical pit, or simply the presence of various soil layers with varying moisture contents.

Analytical results of soil samples taken from borehole BH7-87B indicate various levels of organic contamination, but some level of contamination was present throughout the borehole. A soil sample was taken at 4.3-4.8 feet in depth as a contact sample and was found to have 370 ppb of 2-butanone and 1300 ppb of bis(2-ethylhexyl)phthalate. Similarly a bedrock sample taken from 7.8-9.68 feet in depth contained 66 ppb of 2-butanone and 1600 ppb of bis(2-ethylhexyl)phthalate. The 5-10 foot composite sample contained 79 ppb 2-butanone and 3200 ppb bis(2-ethylhexyl)phthalate), a 9.68-10.35 bedrock composite sample (130 ppb 2-butanone, 1100 ppb bis(2-ethylhexyl)phthalate), and

a 10.35-13.0 foot bedrock sample (2500 ppb bis(2-ethylhexyl)phthalate) all contained organic contamination. There were no other boreholes in the vicinity of SWMU 104.

The analysis of currently available data apparently indicates that SWMU 104 exists. Soil data indicate that contamination extends to a depth of at least 13 feet in areas. However, more data is needed to better define this area. A revised location for SWMU 104 is presented in Plate 3-1.

3.4 SOLID WASTE MANAGEMENT UNIT 105

Two out-of-service #6 fuel oil tanks south of Building 881 had asbestos deposited in the tanks, and the tanks were then filled with concrete that was allowed to harden. These tanks are still in existence and are below grade. Plate 3-1 shows the location of these tanks. Although these tanks were used for asbestos disposal, there seems to be no potential environmental impact from these tanks because they were filled with concrete. Soil gas results in the sampling points near these tanks indicated no volatile organic compounds in the soil gas. No borehole specifically related to SWMU 105 was drilled due to the close proximity of these tanks to Building 881. Borehole BH4-87, the borehole nearest this SWMU unit, does contain oil and grease in the 10-20 foot composite sample at a level of 4.6 ppm. The source of this oil and grease may be residual fuel oil from spills or leaks associated with SWMU 105. An alternative source of this contamination could be oil spills and leaks on the roadway adjacent to the borehole unrelated to SWMU 105. Since these tanks were filled with uncured concrete, there should be little environmental threat posed by the tanks themselves.

3.5 SOLID WASTE MANAGEMENT UNIT 106

This SWMU consists of an outfall pipe south of Building 881 that has discharged water in the past (Plate 3-1). This pipe reportedly is a 6-inch vitrified clay pipe originating from Building 887 (a building with seven process and sanitary waste system tanks and associated piping). Past information indicates that the pipe is a clean-out pipe for an overflow line from the Building 881 cooling tower (DOE 1986b). The location where this pipe daylights was identified during the 1987 field activities; however, the pipe was identified as iron, and no water was flowing from it. Immediately below this pipe a small pond exists, the water of which was sampled on May 26, 1987 (sample SW46). No hazardous substances were found in this sample, but elevated plutonium (0.69 pCi/l) and americium (0.18 pCi/l) were found. This pond is just west and hydraulically upgradient of the skimming pond of SWMU 107. Well 2-87, downgradient of the two ponds mentioned above, also exhibited elevated plutonium (1.3 pCi/l). Analytical results from borehole BH2-87 are not currently available for evaluation. Current data indicates that SWMU 106 is a potential source of contamination and requires further investigaion.

3.6 SOLID WASTE MANAGEMENT UNIT 107

In May 1973, #6 fuel oil from an undetermined source was discovered on the hillside south of Building 881. The oil was believed to be from the fuel oil storage tanks located south of Building 881 (SWMU 105), but leak tests performed on the tanks and associated piping did not show any leakage. The oil spill was contained with straw that was subsequently disposed in the landfill. In 1975 oil was found emerging from an 881 footing drain outfall (DOE 1986b). A dam and skimmer system were built to contain and separate the oil from the footing drain water, and are currently no longer in use. The footing drain and the skimming pond are responsible for the shape of this SWMU,

since the SWMU was defined around the footing drain. See Plate 3-1 for the location of this SWMU.

Geophysical surveys in the area near the 881 footing drain outfall indicated some electromagnetic and magnetic anomalies; however, these anomalies were ascribed to the buried gas pipeline that is present in the immediate area. Volatile organic compounds were not identified in this area by soil gas results. Analytical results for Borehole BH3-87, which is immediately south and west of the 881 footing drain outfall, dam, and skimmer system indicated possible contamination. The contaminants found were bis(2-ethylhexyl)phthalate and 2-butanone (also called methyl-ethyl-ketone or MEK). Bis(2-ethylhexyl)phthalate was found at 700 ppb in the two foot waste sample, at 940 ppb in a 0-9 foot composite sample, at 660 ppb in the 9 foot contact sample, and at 730 ppb in the 12 foot bedrock sample. This contaminant was also found in the water blank, but the concentration was 2 ppb, corresponding to a soil concentration of 60 ppb using the laboratory scale-up factor of 30 (i.e., concentrations in a soil extract are converted to soil concentrations by the factor 30, which considers soil mass extracted and extract volume). Only the 12 foot bedrock sample was above detection limits for 2-butanone. Furthermore, the surface water data for SWMU 107, from the skimming pond, also indicated some contamination with volatile organic compounds. The sample near the north end of the pond (sample SW-45), at the outfall of the 881 footing drain, indicated contamination with 128 ppb of PCE and 14 ppb of TCE. The surface water sample at the discharge of the pond into the South Interceptor Ditch (sample SW-44) contained only 14 ppb of only PCE; TCE was not detected.

These data indicate that the footing drain from Building 881 may be acting as a direct conduit for contaminant migration down the 881 Hillside from other sources, such as SWMU 103. It is not appropriate to estimate contaminated soil volumes for this

SWMU since the source of contamination is probably other SWMU's through which the footing drain passes. The source of some contamination may also be contaminated soil underlying Building 881 and draining into the footing drain during periods of high ground-water levels. SWMU 107 may represent a potential source of contamination.

3.7 SOLID WASTE MANAGEMENT UNIT 119

This SWMU is actually composed of two separate but related areas at which materials were handled. In 1967, two areas east of Building 881 and along the southern perimeter road, south of the Old East Guard Gate, were used as a solvent storage facility. These two areas were enlarged, with the western area (SWMU 119.1) undergoing major expansion in 1971. By April 1972, the facility had been removed. The east area (SWMU 119.2) was a storage facility for non-radioactive barrels. However, at least once radioactive drums were removed from this area. Minor spills and leaks may have occurred at these facilities (DOE 1986b).

3.7.1 Solid Waste Management Unit 119.1

The revised location for this SWMU is shown in Plate 3-1. This location was revised based on 1987 field data and also on the basis that relatively level ground is necessary for drum storage.

Geophysical results at the revised 119.1 SWMU location indicated an electromagnetic anomaly at a location immediately southwest of the revised SWMU location. The cause of this anomaly has not been adequately identified. Likewise, an unexplained conductivity anomaly was identified on the southern portion of the SWMU.

Soil gas results indicated elevated levels of PCE, TCA, and TCE all centered on an area near the location of SWMU 119.1 (Plates 3-3 through 3-5). Both PCE and TCE in

these soil gas results consisted of more than a single elevated reading. PCE was found in elevated levels in six soil gas samples, whereas TCE was found in elevated levels in five samples.

Boreholes BH12-87 and BH14-87 are both located near SWMU 119.1. Soil samples were taken from Borehole BH12-87 from 0-2.25 feet (contact sample) and from 5.25-6.5 feet (bedrock sample). The contact sample had both elevated bis(2-ethylhexyl)phthalate (490ppb) as well as elevated aroclor-1254 (70 ppb). The detection limit for aroclor-1254 is 40 ppb. This contaminant was found in no other soil samples associated with SWMU 119.1. As PCE, TCE, and TCA were not present in the soil but present in the soil gas, it is presumed these compounds are only present in groundwater at this location.

The area near the contaminated soil gas samples boreholes and monitoring wells also contains metal shavings and other manufacturing debris at the soil surface. Four areas with surface radioactivity readings above background also exist in the area near the currently identified SWMU 119.1. No evidence of this SWMU extending to the north and west could be found in either field observations or data. Plate 3-1 shows the revised location of SWMU 119.1. This SWMU could represent a source of contamination for ground water and surface water.

3.7.2 Solid Waste Management Unit 119.2

Geophysical results in the area of SWMU 119.2 indicated only conductivity anomalies. Soil gas results in the SWMU 119.2 location had elevated DCE and TCA readings in an area immediately south of the centerpoint of the SWMU. Both of these elevated readings were made at the same soil gas sampling location, and no other elevated readings were found in the area. The two elevated readings in the same location substantiate that a possible problem may exist in the area.

Soil samples from Boreholes BH16-87 and BH17-87 all had relatively low levels of semi-volatile contamination. Both of these boreholes were located within the approximate limits of SWMU 119.2. BH16-87 is located immediately to the south, and BH17-87 is located immediately to the north of the elevated soil gas reading. A contact sample taken at a depth of 2.5-3.9 feet contained 800 ppb of bis(2-ethylhexyl)phthalate. A sample taken in weathered bedrock from 2-6 feet in depth contained 800 ppb of bis(2-ethylhexyl)phthalate, and the bedrock sample from 7-8.3 feet in depth had 750 ppb of bis(2-ethylhexyl)phthalate. Similarly, the three soil samples gathered from borehole BH17-87 all had elevated levels of bis(2-ethylhexyl)phthalate. The composite sample taken from 0-3.9 feet in BH17-87 had 1200 ppb of bis(2-ethylhexyl)phthalate. The contact sample taken from 3.9 to 5.24 feet had 1300 ppb of bis(2-ethylhexyl)phthalate, and a bedrock sample taken at a depth of 8.25-9.5 had 1500 ppb of the same compound. The detection limit in soil for the above compound is approximately 300 ppb. No other hazardous compounds were detected in elevated concentrations in either borehole. Borehole BH8-87 was located immediately to the west of the proposed 119.2 SWMU location. This borehole had bis(2-ethylhexyl)phthalate present at all depths sampled. This contaminant was present in the 0-7 foot composite sample at 3800 ppb, in the 7 foot contact sample at 3100 ppb, and in the 10 foot bedrock sample at 3700 ppb.

The elevated levels of semi-volatile compound contamination along with the elevated soil gas readings near SWMU 119.2 suggest the presence of a contaminant source. SWMU 119.2 is apparently a potential source of ground and surface water contamination. The existence of a contaminant source cannot currently be definitively confirmed or denied. Additional field work is needed to fully characterize this potential source of contamination. Plate 3-1 indicates the revised location of SWMU 119.2 based on the above 1987 field work.

3.8 SOLID WASTE MANAGEMENT UNIT 130

This is an area east of Building 881 which was used to dispose of approximately 320 tons of plutonium-contaminated soil and asphalt generated from the May 11, 1969 Building 776 fire. This material was buried under 1 to 2 feet of fill, and had an average plutonium activity concentration of 7.4 distingrations per minute per gram (dpm/gm) of soil. Additionally, approximately 60 cubic yards of plutonium-infiltrated soil from the Building 774 waste storage tank was placed in this area. This soil contained an estimated long-lived alpha activity of less than 250 dpm/gm (DOE, 1986b). The location of SWMU 130 has been revised based on 1987 field activities (Plate 3-1).

Geophysical results of work done near the SWMU 130 revised location indicated some unexplained electromagnetic anomalies near the southern edge of the SWMU. However, magnetometer results at the revised SWMU location did not locate any buried metallic items. This suggested that contaminated soil was only buried in this area. Soil gas sampling results indicate only one sampling location with any elevated levels of volatile organic compounds, and this single location was immediately to the west and near the southern edge of the revised SWMU location (Plate 3-3).

Boreholes BH10-87 and BH11-87, both located on the areal extent of the soil fill area, had semi-volatile contamination present at various depths. The concentrations in these soil samples varied from 590 ppb to 1000 ppb for bis(2-ethylhexyl)phthalate. The soil sample depths from BH10-87 were: 0-10, 10-20, 20, and 23 feet. The concentrations of bis(2-ethylhexyl)phthalate were 1000 ppb, 820ppb, 590 ppb, and 730 ppb, respectively for these samples. The 0 to 10 foot soil sample also had calcium at a concentration of 70,800 ppm, which is approximately 100 times greater than the background concentration for calcium (Table 3-2). The bis(2-ethylhexyl)phthalate concentrations for BH11-87

were: 880 ppb (0-10 feet), 760 ppb (11 foot contact sample), and 1000 ppb (14 foot water table sample). The 0 to 10 foot sample also had aroclor-1254 present at a 43 ppb concentration. This concentration is very close to the soil detection limit of 40 ppb, and may be due to lab or field contamination. In general, the bis(2-ethylhexyl)phthalate concentrations found in the soil of both boreholes were several times less concentrated than the concentrations found in other boreholes at the 881 Hillside.

Borehole BH13-87 was located immediately down the hillside from the revised SWMU 130 location. This borehole, similar to the boreholes directly through the revised SWMU location, had elevated bis(2-ethylhexyl)phthalate and calcium in some areas. Bis(2-ethylhexyl)phthalate was found at 1000 ppb in the 0-10 foot composite sample, and at 3500 ppb in the 14 foot bedrock sample. This contaminant was not found in the 11 foot contact sample. Calcium was present at approximately 50 times background concentrations in the 0-10 foot composite sample, and at approximately 100 times background concentrations in the 11 foot contact sample. The contamination found in borehole BH13-87 may possibly have originated from the activities at SWMU 119.1 rather than the SWMU 130 unit.

Field observations indicate the presence of some asphalt rubble and other debris on the rounded areas making up the revised SWMU location. Field observations indicated that the eastern rounded area was placed previous to the western rounded area, based upon the heavier vegetation present on the eastern area. Therefore, it is conjectured that the eastern area may have been the dumping area for the soil originating from the 1969 fire and that the western area may have been the dumping area for the 774 tank soil. The western area is also a possible dumping ground for soil excavated during the construction of an eastern shipping dock on Building 881.

Currently available data does not indicate a source of concentrated contamination at SWMU 130. The contaminant most likely to be present at the SWMU is plutonium; radionuclide results for soil samples are not currently available. These data are needed to adequately define the contamination that may be present at SWMU 130.

3.9 SOLID WASTE MANAGEMENT UNIT 145

In January 1981, the 4 inch diameter cement-asbestos sanitary waste line located south of Building 881 leaked. An earthen dike was placed to prevent the spill from entering the South Interceptor Ditch, and the sanitary waste line was repaired. No hazardous or radioactive materials should have been present in this sanitary waste when the leak occurred, and all waste materials were cleaned up prior to resuming use of the line. Laundry effluent had entered the pipe from 1969 to 1973, but this discharge had been discontinued for eight years before the leak was discovered. Furthermore, soil gas results did not indicate any elevated levels of volatile organic compounds in the area. For these reasons, SWMU 145 is not considered an environmental threat.

3.10 SOLID WASTE MANAGEMENT UNIT 177

SWMU 177 is the Building 885 Drum Storage Area. This area is undergoing RCRA Closure under interim status. Building 885 is currently used for the storage of raw materials and for both satellite collection and 90-day accumulation of RCRA-regulated hazardous waste. These wastes consist of waste solvent and solvent contaminated materials. This SWMU is not a problem since it was not apparently used for the disposal of waste. Any drums of raw materials or waste that leaked or ruptured may have contaminated soil with volatile organic compounds near the building, but large concentrations of such contaminants would have been identified in the soil gas analyses. Such contamination was not found. The location of SWMU 103 has been revised, and is now

currently believed to be covering a portion of Building 885. SWMU 177 does not represent a source of ground or surface water contamination.

3.11 SUMMARY

Based on data available to date, SWMU's 102, 105, 145, and 177 are not considered potential sources of ground water or surface water contamination. SWMU's 103, 106, 107, and 119 do appear to be potential sources of ground-water contamination. More data are required to adequately characterize SWMUs 104 and 130, potential sources of ground-water and surface water contamination.

The primary contaminant found in soil at the 881 Hillside Area appears to be bis(2-ethylhexyl)phthalate. This compound is a commonly used plasticizer and a commom laboratory contaminant. This compound is also a widely distributed compound in the environment (Department of Health and Human Services 1985), and can also be found in petroleum wastes (API 1984). The primary source of bis(2-ethylhexyl)phthalate in the 881 Hillside soil is conjectured to be hydraulic oil used as a cutting lubricant in various machining operations and later disposed on the 881 Hillside soil. Additional data is needed to definitively identify the presence and source of bis(2-ethylhexyl)phthalate at the 881 Hillside Area.

The toxicity of bis(2-ethylhexyl)phthalate has been extensively studied. A study of phthalate esters, including bis(2-ethylhexyl)phthalate, found that these compounds have an extremely low order of toxicity for small laboratory animals. The acute oral LD50 ranges from 26.3 g/kg for the mouse to 33.8 g/kg for the rat. The LD50 value for intraperitoneal injection was found to be 14.2 g/kg in the mouse, and over 50 g/kg in the rat. Chronic oral toxicity studies conducted from 90 days to 2 years in the rat, one year in the guinea pig, and up to one year in the dog, have established a no effect oral

dose of approximately 60 mg/kg/day. Higher doses resulted in slowed growth and increased weight of livers and kidneys. No increased incidence of trumors or histological abnormalities were found. A tissue distribution, metabolism and excretion study for this compound, by both intraperitoneal and dermal administration, found no appreciable metabolism of bis(2-ethylhexyl)phthalate, with clearance of the compound chiefly through urinary excretion. This compound was also found to be poorly absorbed through the skin, and no irritant response from dermal application or senistizing potential were noted. Long-term storage of this compound in biological tissues was not found (ACGIH 1986).

Bis(2-ethylhexyl)phthalate was also studied for carcinogenicity. The National Cancer Institute (NCI) conducted a lifetime feeding study on rats and mice. NCI found that high dose levels caused liver tumors in rats and mice, but two previous prolonged feeding studies with rats at lower dose levels did not produce liver tumors. The Chemical Manufacturers Association (CMA) also studied this compound, and found that bis(2-ethylhexyl)phthalate, unlike most other carcinogenic chemicals, did not cause tumors by damaging genetic material. At high dose levels this compound caused changes in the liver cells of mice and rats. These changes at high dose levels may be unique to mice and rats, and may not occur in humans or other animals (CMA 1984). Bis(2-ethylhexyl)phthalate is almost insoluble in water, and has a high preference to partition into sediments or soils, see Table 3-3. Overall, this compound is relatively nontoxic.

Other contaminants found at above background levels at the 881 Hillside Area include various volatile organic compounds. Table 3-3 presents physical and chemical data for these compounds.

TABLE 3-3

PHYSICAL AND CHEMICAL CHARACTERISTICS OF HAZARDOUS CONSTITUENTS IDENTIFIED AT THE 881 HILLSIDE

HAZARDOUS CONSTITUENTS	DENSITY (gm/cm^3)	MOLECULAR WEIGHT	WATER SOLUBILITY: QUALITATIVE	WATER SOLUBILITY: PPM	OCTANOL/WATER PARTITION COEF.	VAPOR PRESSURE @20°C, 760 TORR	MELTING POINT °C, 760 TORR	BOILING POINT °C, 760 TORR	CAS #	REFERENCE	MATRIX*
Trichloroethene	1.45	133.34	Slightly soluble	1,100	194.98	57.9	-73	87	79-01-6	EPA 1984	GW, S, SW
1,1,1-Trichloroethane	1.33	133.41	Slightly soluble	$4.4x10^3$	158.49	96.0	-30.41	74.1	71-55-6	EPA 1984	GW, S
1,1,2-Trichloroethane	1.44 (sp.gr.)	133.41	Slightly soluble	>200	147.90	19	-36.5	113.77	79-00-5	EPA 1984	GW, S
Tetrachloroethene	1.62	165.83	Slightly soluble	~175	758.58	14	-22.7	121	127-18-4	EPA 1984	GW, S, SW
1,1-Dichloroethane	1.17	98.96	Almost insoluble	5.50	61.66	180	-96.98	57.28	75-34-3	EPA 1984	GW, S
1,2-Dichloroethane	1.26	98.96	Highly soluble	8,700	31.62	61	-35.36	83.47	107-06-2	EPA 1984	GW, S
1,1-Dichloroethene	1.21	97.0	Insoluble	-----	-----	82.28	-122.53	37 @ 101 Kpa	75-35-4	EPA 1984	GW, S
t,1,2-Dichloroethene	1.27 @ 25°C	96.94	Slightly soluble	600	30.20	200 @ 14°C	-50	47.5	540-59-0	EPA 1984	GW
2-Butanone	0.80 (sp.gr.)	72.1	Very soluble	100,000 @ 25°C	1	71.2	-86.75	76.6	--------	EPA 1984	GW
Carbon Tetrachloride	1.84 (sp.gr.)	153.82	Slightly soluble	1,000 @ 25°C	436.5	90.0	-22.9	76.54	56-23-5	EPA 1984	GW
Bis (2-ethylhexyl)-Phthalate	0.985	391.0	Almost insoluble	0.9 @ 25°C	199×10^5	2×10^{-7}	-50	386.9 @ 5 TORR	117-81-7	EPA 1984	S
Methylene Chloride	1.33 (sp.gr.)	84.9	Highly soluble	20,000	19.9	380	-95	39.75	75-09-2	EPA 1984	S
4-Methyl-2-Pentanone	0.80	----	Slightly soluble	------	------	15.7	-----	115.8	108-10-1	**	S
Aroclor-1254 (PCB)	1.5	----	----	------	------	-----	-----	-----	1336-36-3	**	S
Acetone	0.79 @ 15°C	58.08	Miscible	------	------	400 @ 34.5°C	-95.4	56.2	67-64-1	SW-874	S

* Matrix indicates where compound found at 881 Area; S = Soil, GW = Groundwater, SW = Surface Water

** Sax, N.I. and R.J. Lewis, Sr., 1987, Hawley's Condensed Chemical Dictionary, 11th edition, Van Nostrand Reinhold, New York, New York.

4.0 GROUND WATER

This section describes the results of the hydrogeologic investigation of the 881 Hillside Area. The discussions are based on data from 12 borings and wells drilled during the period 1974 to 1986, 7 new wells, and 19 new borings (Plate 4-1). The new drilling program is described in detail in Appendix C, and the hydrogeologic data are presented in Appendix D. Soil and water sampling results are presented in Appendix E.

This section begins with descriptions of the soil and bedrock materials at the site, with emphasis on their hydrologic properties. Then the inter-relationship of ground water in the soils and bedrock is described, as well as the interaction between ground and surface water. Finally detailed discussions of the ground-water flow systems and water quality are provided for the SWMUs identified in Section 3.

4.1 SOILS/ALLUVIAL MATERIALS

The 881 Hillside is located on the southern flank of the Plant on a slope from the Rocky Flats surface down to Woman Creek. Surficial materials consist of the Rocky Flats Alluvium, colluvium, artificial fill, and valley fill alluvium. Each of these materials is described in detail below, based on drilling data from the 881 Hillside. Plate 4-2 presents the surficial distribution of geologic units.

4.1.1 Rocky Flats Alluvium

The Rocky Flats Alluvium consists of a gravelly sand with some silt layers in the vicinity of the 881 Hillside and varies in thickness from approximately four to twenty feet. The hydraulic conductivity varies with the grain size of the materials, generally in the range of 1x10-4 to 1x10-3 centimeters per second (cm/s). Tests of the Rocky Flats Alluvium are described in Hydro-Search (1985) and Rockwell International (1986a).

Table 4-1. Summary of Geohydrologic Data

Well	Test	Material	Depth of Test Interval (feet)	Conduc- tivity (cm/s)	Stor- age Coef.	Remark
9-74	no	cs/coll.	-	-	-	
10-74	no	colluvium	-	-	-	
1-82	no	colluvium	-	-	-	
2-82	no	colluvium	-	-	-	
58-86	no	valley fill	-	-	-	Dry in 1986
59-86BR	dd-rec	sandstone	23.5-26.5	3x10-4	-	Unconfined
61-86	no	Rocky Flats	-	-	-	
62-86BR	-	sandstone	-	-	-	
63-86	no	colluvium	-	-	-	Thin gravel
64-86	no	valley fill	-	-	-	
68-86	dd-rec	valley fill	0.9-2.8	1x10-3	-	
69-86	dd-rec	colluvium	11.0-12.5	5x10-4	.038	Thin gravel
1-87	no	art. fill	-	-	-	Dry
2-87	dd-rec	fill/coll?	2.5-8.8	4x10-5	.1	
	slug	fill/coll?	2.5-8.8	3x10-5	-	
3-87BR	dd-rec	sandstone	103.1-106.3	3x10-6	-	
	packer	unwthd. cs	62.9-72.6	2x10-8	-	
	packer	unwthd. cs	74.6-84.2	4x10-8	-	
	packer	unwthd. cs	88.2-97.8	1x10-8	-	
	packer	sandstone	97.8-107.5	4x10-7	-	See dd-rec
4-87	dd-rec	colluvium		5x10-4	-	Thin gravel
5-87BR	dd-rec	ss & frac. cs	44.9-51.3	7x10-5	-	Unconfined
	packer	wthd. cs	26.4-36.0	2x10-6	-	
	packer	wthd. cs	36.0-45.7	1x10-6	-	
	packer	ss & frac. cs	45.7-55.4	5x10-7	-	See dd-rec
6-87	-	colluvium	-	-	-	Reportd dry
8-87BR	dd-rec	lignite	86.0-88.0	3x10-6	-	
	packer	wthd. cs	62.6-72.3	7x10-7	-	
	packer	lignite	83.4-93.1	9x10-8	-	See dd-rec

Notes:
ss = sandstone
cs = claystone
dd-rec = drawdown/recovery
frac. = fractured
art. fill = artificial fill
wthd. = weathered
unwthd. = unweathered

bedrock of similar grain size), and the gravel has a hydraulic conductivity of approximately 5x10-4 cm/s (wells 69-86 and 4-87).

4.1.4 Valley Fill Alluvium

The valley fill alluvium occurs along Woman Creek and is the most recently reworked natural material. The alluvium is a gravel with pebbles and cobbles and some sand. The alluvium consists of re-deposited Rocky Flats Alluvium on top of bedrock, and it is relatively thin (four to eight feet thick, where present). The hydraulic conductivity is on the order of 1x10-3 cm/s (well 68-86).

4.2 BEDROCK MATERIALS

Bedrock beneath the 881 Hillside consists of claystones, siltstones, lignite, and sandstones of the Arapahoe Formation. Based on correlation of the top of the sandstones in 5-87BR and 7-87BRA (Plate 4-3), bedrock is dipping approximately 7 degrees to the east. Based on the available drilling data, most of the bedrock immediately beneath the soils at the 881 Hillside is weathered claystone. Weathering appears to penetrate between twenty and forty feet into the bedrock and is characterized by hues of yellow and green, more intense fracturing (frequently iron-stained), and higher hydraulic conductivities. The hydraulic conductivity of weathered claystone is in the range of 7x10-7 to 7x10-5 cm/s (5-87BR and 8-87BR). The hydraulic conductivity of unweathered claystone is in the range of 1x10-8 to 4x10-8 cm/s (3-87BR).

Water bearing zones in the bedrock apppear to consist primarily of relatively thin (less than 6 feet), fine to very fine-grained sandstones. The sandstones are sometimes silty and/or clayey and appear to be discontinuous along both strike and dip (Plate 4-3). The hydraulic conductivity of the sandstones ranges from 3x10-6 to 3x10-4 cm/s (59-86BR and 3-87BR). Lignite may also serve as a water bearing zone in the bedrock and

was encountered in wells 3-87BR and 8-87BR (one and three feet thick, respectively). Well 8-87BR was completed in the three foot thick lignite zone. The hydraulic conductivity of the lignite is approximately 1x10-6 cm/s.

4.3 GROUND-WATER FLOW

4.3.1 General Vicinity

Ground water occurs in both the soil and bedrock materials in the general vicinity of the Rocky Flats Plant. The major source of recharge is infiltration of incident precipitation into the Rocky Flats Alluvium, although seepage from ditches and streams also contributes to the recharge. Most of the infiltrated water flows toward the drainages on top of the relatively impermeable Upper Laramie and Arapahoe Formation claystones, or it flows to the east within the Rocky Flats Alluvium. The eastward flow is strongly controlled by the buried topography of the pediment, diverted around the bedrock highs and flowing in the buried paleo-channels. A bedrock high east of Building 881 causes diversion of ground-water flow and results in unsaturated alluvium in the area (Hurr, 1976 and Rockwell International, 1986a). The unsaturated area may also be influenced by bedrock lithology.

Some of the water in the Rocky Flats Alluvium emerges as seeps and springs at the contact between the alluvium and bedrock (contact seeps), most of which is consumed by evapotranspiration. In addition, some of the water is carried in the colluvium to the valley fill alluvium where it either flows down-valley in the alluvium, is consumed by evapotranspiration, or surfaces to augment stream flow. During the driest periods of the year, evapotranspiration can be so intense that there is no flow in the valley fill alluvium.

Some of the ground water in the various soil deposits also enters the bedrock flow system either across the claystones to the sandstones (very small quantity flows) or directly into sandstone units in areas where sandstones (and other water bearing materials) subcrop beneath the soils. Water in the Arapahoe Formation flows generally to the east at a gradient of about 0.03 (Hurr, 1976).

4.3.2 881 Hillside

Ground-water at the 881 Hillside also occurs in both the soil and bedrock materials. However, flow appears to be strongly influenced by two factors. The first is a series of foundation drains around Building 881. The drains join to form a single gravity discharge that flows at about 5 gallons per minute (measured June 25, 1987) into the pond at SWMU 107 and then into the South Interceptor Ditch. The result is nearly complete drainage of the Rocky Flats Alluvium in the vicinity of the building (no recharge to colluvium on upper slope) and nearly complete saturation of the colluvium at and downstream of the pond in SWMU 107. The second factor is the presence of unsaturated Rocky Flats Alluvium up-slope of the site everywhere east of Building 881 (caused by a bedrock high and possibly by bedrock lithology, as discussed in the preceding section). This results in less recharge to the colluvium and valley fill alluvium from this area.

In general, however, ground water moves from the Rocky Flats Alluvium, into the colluvium, and enters the valley fill alluvium (Plate 4-4). Where the Rocky Flats Alluvium is dry, the colluvium is recharged by infiltration of incident precipitation (low quantity because of the clayey nature of surficial soil) and by flow from more permeable bedrock units. It is likely that most of the flow in the colluvium occurs in the basal gravel layer in the paleo-channels off the pediment surface, because the gravel deposits are capable of draining the limited recharge to the colluvium.

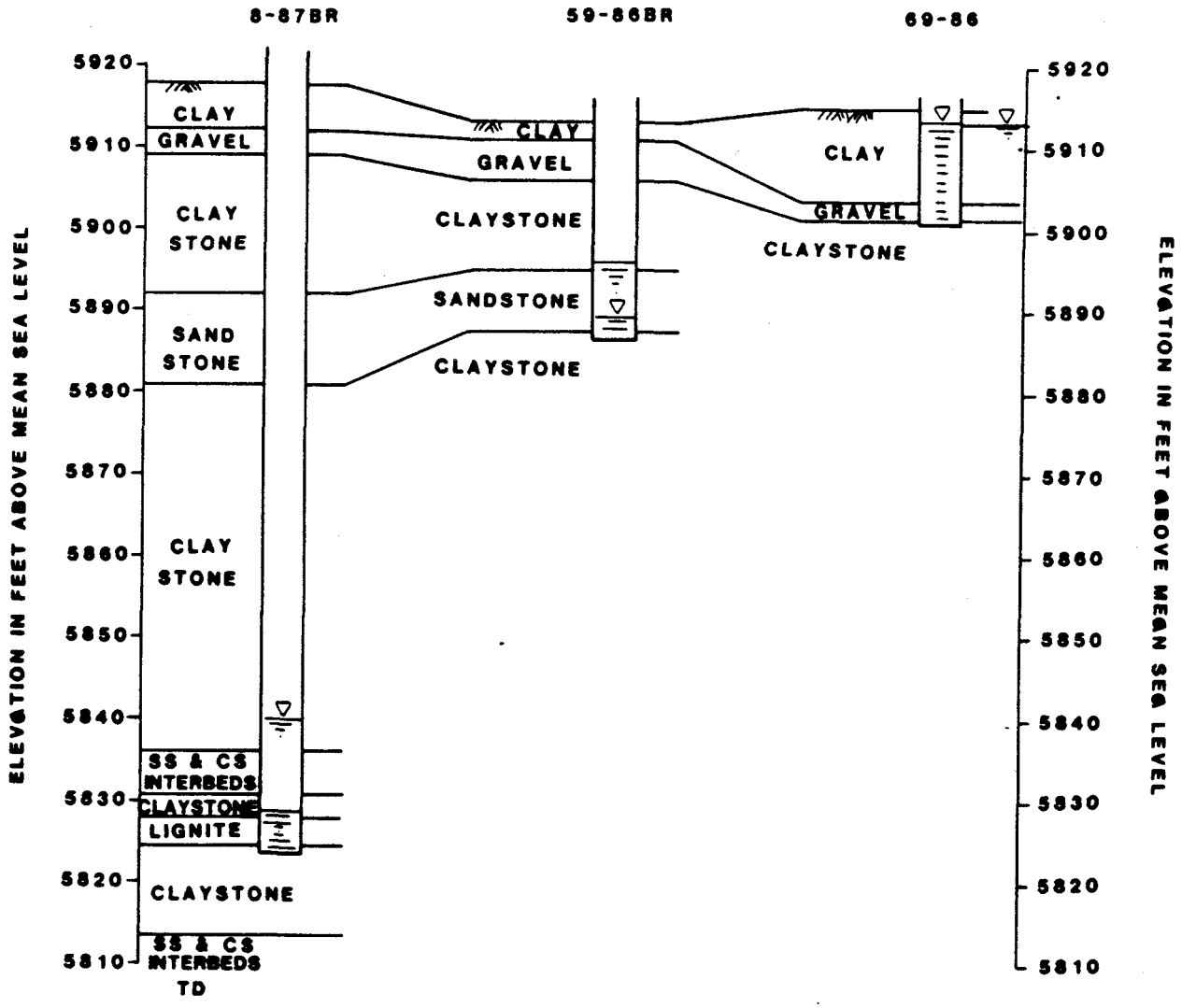
There is a strong downward hydraulic gradient between ground water in the soils and in the bedrock, and between water bearing zones in the bedrock. This has been shown previously at the Plant (Hurr, 1976; Rockwell International, 1986a) and is again demonstrated by new data from the three well cluster consisting of 59-86BR, 69-86, and 8-87BR (Figure 4-1). Based on data collected June 24, 1987, ground water in the colluvium (69-86) is nearly at the ground surface while ground water in the first sandstone (separated from the colluvium by an 11 foot flow path through claystone in well 59-86BR) is 25 feet lower. In fact, the ground water in the sandstone in 59-86BR is unconfined (sandstone is not fully saturated). The calculated gradient is well in excess of 1, i.e., the direct hydraulic connection is broken by the unsaturated sandstone. Flow through the claystone is therefore under a unit gradient (assuming constant moisture content) and is controlled by the vertical hydraulic conductivity of the weathered claystone. This conductivity is probably on the order of 1x10-7 cm/s (slightly less than the low end of the range of horizontal hydraulic conductivities for the material). Flow through the claystone is definitely less than can be removed by the sandstone (hydraulic conductivity of 1x10-4 cm/s under a reported gradient of 0.03). The downward gradient between water bearing zones in the bedrock is also nearly one (Figure 4-1); although the lignite in well 8-87BR is fully saturated (slightly confined).

The ground-water pathways from the SWMUs are:

1) through the colluvium to the valley fill alluvium, and then exiting the property as surface (Woman Creek) or subsurface flow,

2) through the colluvium to emerge at the South Interceptor Ditch and leave the property as surface water flow, and

3) through the colluvium to the water bearing zones of the bedrock, and then exiting the property in the bedrock.



WATER LEVEL - MEASURED 6/24/87

COMPLETION ZONE

GROUND SURFACE ELEVATION ASSUMED FOR 69-86. ALL OTHERS BASED ON SURVEY DATA.

NO HORIZONTAL SCALE

WESTON
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 4-1

DIAGRAM OF VERTICAL POTENTIOMETRIC CONDITIONS

Flow velocities in the colluvial gravels (where saturated) may be as high as 2 feet per day, assuming an effective porosity of 0.1 and using the topographic gradient of about 0.16. Flow velocities in the clayey colluvium are probably about 0.2 feet per day (same assumptions). The flow velocity in the valley fill alluvium near the 881 Hillside is approximately 1 foot per day, assuming an effective porosity of 0.1 and using the topographic gradient of about 0.04; however, contaminants would not move the implied 365 feet per year because the alluvium is not saturated during the entire year. Transport velocities in the sandstone bedrock appear to be on the order of 0.3 feet per day, assuming an effective porosity of 0.1 and using a gradient of 0.03 (Hurr, 1976).

All of the materials encountered in the investigation have too little saturated thickness and available drawdown (soils) or are too impermeable (sandstones and claystones) to produce usable quantities of ground water at the 881 Hillside area. The best wells might produce one gallon per minute (specific capacity of 0.1 gallons per minute per foot of drawdown in the gravels and 0.01 gallons per minute per foot of drawdown in the sandstones).

4.4 GROUND-WATER CONTAMINATION

This section describes the ground-water flow systems and ground-water contamination at each of the SWMUs identified as potential contaminant sources in Section 3. Localized degraded ground-water quality has been found in the vicinity or downgradient of three of the SWMUs.

4.4.1 Solid Waste Management Units 103, 106, 107 and 177

These SWMUs are located in an area immediately south of Building 881 that was used for disposal (103) and storage (177) of various oils and solvents. SWMU 177 is currently in use. The west end of these units are underlain by a gravel layer (possibly a

gravel road) up to two feet thick which rests directly on claystone bedrock (BH1-87). On the east end of the unit (BH4-87), there is a 15 feet thick gravel layer and ground water is at a depth of approximately 10.5 feet. Downslope, artificial fill (reworked bedrock) approximately 4.5 feet thick overlies undisturbed claystone bedrock (BH5-87).

SWMU 107 consists of a fuel oil spill from an unknown source that was contained in the pond at the unit (pond outfall designated SW-44). The No. 6 fuel oil observed on the slope probably leaked from the No. 6 fuel oil tanks (SWMU 105) into the bedding material around the tanks and then into the foundation drain. The oil appeared at the outfall from the drain and was contained by construction of a skimming pond that is still in place today. Samples of the pond inflow (SW-45) and outflow (SW-44) did not indicate fuel oil contamination; however, tarry residue was observed in the banks of the pond. The unit is underlain by clayey sand and sandy clay to a depth of 8.8 feet where claystone bedrock occurs. Depth to water in the soil is quite shallow (1 to 2 feet).

SWMU 106 consists of an iron pipe exposed on the 881 Hillside below the building. Based on recent erosion beneath the pipe, discharge has occurred in the last two to three years, and is directed to a small pond (SW-46). The unit is founded on artificial fill (reworked bedrock). The stratigraphy at the unit is probably similar to that at BH2-87, i.e., colluvium underlain by claystone bedrock.

Ground-water flow from most of these units (areas directly south of Building 881) is to the south toward wells 2-87 and 3-87BR. To some extent, ground-water flow is probably controlled by the footing drain of Building 881 and other utility trenches. The drain discharges through a corrugated metal pipe into the pond at SWMU 107 (SW-44). The pipe typically flows under partially full conditions and the flow rate was 5 gallons per minute on June 25, 1987. A sample of the pipe discharge (SW-45) contains volatile

organic compounds (tetrachloroethene at 128 ppb and trichloroethene at 14 ppb) but does not contain elevated radionuclide concentrations. However, the pond (SW-44) contains elevated Pu (.31 pCi/l) and Am (.70 pCi/l), and the only volatile detected was tetrachloroethene (4 ppb). This suggests that volatilization of organics occurs in the pond, but another source of radionuclides may exist. Elevated Pu (.69 pCi/l) and Am (.18 pCi/l) occurs at SWMU 106, the small pond (SW-46) just west and hydraulically upgradient of this pond. Elevated Pu (1.3 pCi/l) is also observed at well 2-87 (Table 4-2), just south of the ponds. It is therefore inferred that both ponds are a part of the alluvial ground-water system and that the ground water in this location has elevated organics, Pu and Am, probably originating from SWMUs 103, 106, and 107. Samples from wells 2-87 and 3-87BR do not contain volatile organics. Strontium was not detected in the 881 Hillside surface water samples (less than 0.2 mg/l) and is at background concentrations in wells 2-87 and 3-87BR (0.61 and 0.46 mg/l, respectively).

4.4.2 Solid Waste Management Units 104 and 130

SWMU 104 is an area used for dumping of liquids prior to 1969. The exact location of the unit is unknown but has been located on the Rocky Flats Alluvium where soil gas volatile organics were detected. The Rocky Flats Alluvium directly underlies the unit and consists of sandy gravel with cobbles (61-86A). The depth is highly variable in this area, probably on the order of ten feet. BH7-87 data suggest bedrock is probably claystone.

SWMU 130 consists of a soil-covered pile of debris from the 1969 Building 776 fire (approximately 320 tons) and is due south of SWMU 104. The debris is mostly plutonium contaminated soil with very little construction debris (BH10-87). In addition, approximately 60 cubic yards of plutonium contaminated soil were placed here from the Building 774 waste storage tank area. The unit consists of 2 feet of clayey sand cover

Table 4-2. Ground-Water Chemistry Results 881 Hillside Investigation

Well	2-87	3-87BR	4-87
Date	05/29/87	06/16/87	05/20/87
Cl (mg/l)	66.0	93.9	200
NO3 as N (mg/l)	<0.20	.32	5.80
SO4 (mg/l)	99.0	210	310
TDS (mg/l)	547	470	1318
HCO3 (mg/l)	275	192	309
CN (ug/ml)	<1.0	<1.0	<1.0
Oil & Grease (mg/l)	12.9	76.9	6.7
Cr+6 (mg/l)	<1.0	<1.0	<1.0
Radiochemistry			
Gross Alpha (pCi/l)	130+/-17	811+/-76	220+/-10
Gross Beta (pCi/l)	100+/-12	177+/-60	134+/-15
U-234 (pCi/l)	(1.0+/-0.3)x10+1	<	(2.3+/-0.3)x10+1
U-235 (pCi/l)	(8.4+/-7.1)x10-1	<	(9.5+/-6.6)x10-1
U-238 (pCi/l)	6.6+/-1.9	<	(0.5+/-0.3)x10+1
Sr-90 (pCi/l)	.74	<0.6	4.50
Pu-239 (pCi/l	1.3+/-0.9	<	0.0+/-0.0
Am-241 (pCi/l)	0.0+/-5.9	<	0.0+/-2.4
Tritium (pCi/l)	1.2x10+2	<	<1.1x10+2
Cs-137 (pCi/l)	1.4	<	3.1
Metals			
Ag (mg/l)	<0.01	<0.01	<0.01
Al (mg/l)	<0.2	<0.2	.3
Ba (mg/l)	<0.2	<0.2	<0.2
Be (mg/l)	<0.005	<0.005	<0.005
Ca (mg/l)	64.5	24.4	183
Co (mg/l)	<0.05	<0.05	<0.05
Cr (mg/l)	<0.01	<0.01	<0.01
Cu (mg/l)	<0.025	<0.025	<0.025
Fe (mg/l)	<0.1	<0.1	.2
Mg (mg/l)	19.2	6.46	39.1
Mn (mg/l)	.22	<0.015	.12
Mo (mg/l)	<0.04	<0.04	<0.04
Na (mg/l)	125	143	228
Ni (mg/l)	<0.04	<0.04	<0.04
Sr (mg/l)	.61	.46	1.3
V (mg/l)	<0.05	<0.05	<0.05

Well	2-87	3-87BR	4-87
Date	05/29/87	06/16/87	05/20/87
Volatiles (ug/l)			
Chloroform	-	<4	<4
Carbon Tetrachloride	-	<4	5
1,1-Dichloroethene	-	<4	8
1,2-Dichloroethane	-	<4	32
1,1,1-Trichloroethane	-	<4	<4
1,1,2-Trichloroethane	-	<4	<4
Trichloroethene	-	<4	525
Tetrachloroethene	-	<4	84
Trans-1,2-Dichloroethene	-	<4	<4
Metals			
As (mg/l)	<0.01	<0.01	<0.01
Pb (mg/l)	<0.005	.008	<0.005
Hg (mg/l)	.0003	<0.0002	<0.0002
K (mg/l)	<5.0	13	<5.0
Se (mg/l)	<0.005	<0.005	.193
Tl (mg/l)	<0.01	<0.01	<0.01
Cs (mg/l)	<0.2	<0.2	<0.2
Li (mg/l)	.02	.06	.02
Sb (mg/l)	<0.06	<0.06	<0.06
Cd (mg/l)	<0.005	<0.005	<0.005
Zn (mg/l)	.02	<0.02	.16
Tests of Data			
Sum of Cations (meq/l)	10.24	8.30	22.27
Sum of Anions (meq/l)	8.43	10.19	17.58
Cation-Anion Balance	9.67%	-10.21%	11.77%
TDS Calculated (mg/l)	630	678	1256
TDS Calc./Determined	1.15	1.44	.95
Major Ion Water Type			
Ca	31%	15%	41%
Mg	15%	6%	14%
Na+K	53%	79%	45%
Cl	22%	26%	32%
SO4	24%	43%	37%
HCO3+CO3	53%	31%	29%

Well	5-87BR	8-87BR
Date	06/12/87	06/15/87
Cl (mg/l)	166	40.1
NO3 as N (mg/l)	9.5	<0.20
SO4 (mg/l)	345	770
TDS (mg/l)	1314	1232
HCO3 (mg/l)	389	266
CN (ug/ml)	<1.0	<1.0
Oil & Grease (mg/l)	204	117
Cr+6 (mg/l)	<1.0	<1.0
Radiochemistry		
Gross Alpha (pCi/l)	64+/-9	87+/-86
Gross Beta (pCi/l)	80+/-41	117+/-4
U-234 (pCi/l)	(1.5+/-0.3)x10+1	<
U-235 (pCi/l)	(7.2+/-6.1)x10-1	<
U-238 (pCi/l)	9.4+/-2.2	<
Sr-90 (pCi/l)	<0.6	<
Pu-239 (pCi/l	0.0+/-0.0	2.1+/-1.8
Am-241 (pCi/l)	0.0+/-2.7	<
Tritium (pCi/l)	<1.1x10+2	<1.1X10+2
Cs-137 (pCi/l)	2.0	<0.3
Metals		
Ag (mg/l)	<0.01	<0.01
Al (mg/l)	<0.2	<0.2
Ba (mg/l)	<0.2	<0.2
Be (mg/l)	<0.005	<0.005
Ca (mg/l)	196	123
Co (mg/l)	<0.05	<0.05
Cr (mg/l)	<0.01	<0.01
Cu (mg/l)	<0.025	<0.025
Fe (mg/l)	<0.1	<0.1
Mg (mg/l)	55.5	35.8
Mn (mg/l)	.10	.050
Mo (mg/l)	<0.04	<0.04
Na (mg/l)	125	259
Ni (mg/l)	<0.04	<0.04
Sr (mg/l)	2.3	2.0
V (mg/l)	<0.05	<0.05

Well	5-87BR	8-87BR
Date	06/12/87	06/15/87
Volatiles (ug/l)		
Chloroform	<4	<4
Carbon Tetrachloride	<4	<4
1,1-Dichloroethene	<4	<4
1,2-Dichloroethane	6	<4
1,1,1-Trichloroethane	<4	<4
1,1,2-Trichloroethane	<4	<4
Trichloroethene	<4	<4
Tetrachloroethene	<4	<4
Trans-1,2-Dichloroethene	<4	<4
Metals		
As (mg/l)	<0.01	<0.01
Pb (mg/l)	<0.005	<0.005
Hg (mg/l)	<0.0002	.0003
K (mg/l)	11	20
Se (mg/l)	.052	<0.005
Tl (mg/l)	<0.01	<0.01
Cs (mg/l)	<0.2	<0.2
Li (mg/l)	.35	.12
Sb (mg/l)	<0.06	<0.06
Cd (mg/l)	.008	<0.005
Zn (mg/l)	.07	<0.02
Tests of Data		
Sum of Cations (meq/l)	20.06	20.86
Sum of Anions (meq/l)	18.92	21.52
Cation-Anion Balance	2.94%	-1.56%
TDS Calculated (mg/l)	1274	1478
TDS Calc./Determined	.97	1.20
Major Ion Water Type		
Ca	49%	29%
Mg	23%	14%
Na+K	29%	56%
Cl	25%	5%
SO4	38%	74%
HCO3+CO3	34%	20%

Well	9-74	59-86	59-86
Date	--/--/87	04/09/87	04/30/87
Cl (mg/l)	378	66.7	78.5
NO3 as N (mg/l)	34	1.28	1.40
SO4 (mg/l)	173	150	175
TDS (mg/l)	1536	874	812
HCO3 (mg/l)	231	329	493
CN (ug/ml)	<1.0	<1.0	<1.0
Oil & Grease (mg/l)	-	-	-
Cr+6 (mg/l)	-	-	-
Radiochemistry			
Gross Alpha (pCi/l)	100+/-27	33+/-7	45+/-17
Gross Beta (pCi/l)	121+/-21	37+/-13	58+/-14
U-234 (pCi/l)	6.6+/-1.2	(1.1+/-0.3)x10+1	(1.5+/-0.2)x10+1
U-235 (pCi/l)	(4.1+/-3.6)x10-1	0.7+/-1.3	(8.8+/-5.8)x10-1
U-238 (pCi/l)	5.4+/-1.1	5.6+/-2.9	(1.1+/-0.2)x10+1
Sr-90 (pCi/l)	<0.6	<0.6	2.41
Pu-239 (pCi/l	(5.5+/-3.9)x10-1	(0.0+/-6.4)x10-1	1.3+/-1.0
Am-241 (pCi/l)	6.6+/-3.9	0.0+/-1.0	(0.0+/-5.5)x10-1
Tritium (pCi/l)	1.1x10+2	4.5x10+2	<1.1X10+2
Cs-137 (pCi/l)	-	-	
Metals			
Ag (mg/l)	-	<0.01	<0.01
Al (mg/l)	-	<0.2	<0.2
Ba (mg/l)	-	<0.2	<0.2
Be (mg/l)	-	<0.005	<0.005
Ca (mg/l)	-	131	124
Co (mg/l)	-	<0.05	<0.05
Cr (mg/l)	-	<0.01	<0.01
Cu (mg/l)	-	<0.025	<0.025
Fe (mg/l)	-	<0.1	<0.1
Mg (mg/l)	-	41.4	40.1
Mn (mg/l)	-	.036	.048
Mo (mg/l)	-	<0.04	<0.04
Na (mg/l)	-	146	145
Ni (mg/l)	-	.046	.11
Sr (mg/l)	-	1.3	1.2
V (mg/l)	-	<0.05	<0.05

Well	9-74	59-86	59-86
Date	--/--/87	04/09/87	04/30/87
Volatiles (ug/l)			
Chloroform	<4	<4	<4
Carbon Tetrachloride	<4	<4	<4
1,1-Dichloroethene	12400	<4	<4
1,2-Dichloroethane	75	<4	<4
1,1,1-Trichloroethane	13800	<4	<4
1,1,2-Trichloroethane	96	<4	<4
Trichloroethene	20000	<4	<4
Tetrachloroethene	6400	<4	<4
Trans-1,2-Dichloroethene	48	<4	<4
Metals			
As (mg/l)	-	<0.01	<0.01
Pb (mg/l)	-	<0.005	<0.005
Hg (mg/l)	-	<0.0002	<0.0002
K (mg/l)	-	<5.0	<5.0
Se (mg/l)	-	.06	.044
Tl (mg/l)	-	<0.01	<0.01
Cs (mg/l)	-	<0.2	<0.2
Li (mg/l)	-	-	-
Sb (mg/l)	-	<0.06	<0.06
Cd (mg/l)	-	<0.005	<0.005
Zn (mg/l)	-	<0.02	.02
Tests of Data			
Sum of Cations (meq/l)	.00	16.29	15.79
Sum of Anions (meq/l)	20.48	10.49	14.04
Cation-Anion Balance	-100.00%	21.68%	5.88%
TDS Calculated (mg/l)	933	828	1022
TDS Calc./Determined	.61	.95	1.26
Major Ion Water Type			
Ca	ERROR	40%	39%
Mg	ERROR	21%	21%
Na+K	ERROR	39%	40%
Cl	52%	18%	16%
SO4	18%	30%	26%
HCO3+CO3	18%	51%	58%

Well	61-86	61-86
Date	03/11/87	05/05/87
Cl (mg/l)	9.25	3.58
NO3 as N (mg/l)	1.10	1.70
SO4 (mg/l)	36.0	21.0
TDS (mg/l)	234	236
HCO3 (mg/l)	171	177
CN (ug/ml)	<1.0	<1.0
Oil & Grease (mg/l)	-	-
Cr+6 (mg/l)	-	-
Radiochemistry		
Gross Alpha (pCi/l)	1+/-10	18+/-15
Gross Beta (pCi/l)	16+/-9	46+/-13
U-234 (pCi/l)	4.2+/-1.2	3.9+/-1.2
U-235 (pCi/l)	(6.5+/-0.3)x10+2	(0.8+/-3.5)x10-1
U-238 (pCi/l)	2.7+/-0.9	2.1+/-0.9
Sr-90 (pCi/l)	<0.6	1.90
Pu-239 (pCi/l	(6.6+/-5.3)x10-1	(7.0+/-6.6)x10-1
Am-241 (pCi/l)	(0.0+/-7.4)x10-1	(4.3+/-4.3)x10-1
Tritium (pCi/l)	<1.1X10+2	2.0x10+2
Cs-137 (pCi/l)	-	-
Metals		
Ag (mg/l)	<0.01	<0.01
Al (mg/l)	<0.2	<0.2
Ba (mg/l)	<0.2	<0.2
Be (mg/l)	<0.005	<0.005
Ca (mg/l)	56.2	63.2
Co (mg/l)	<0.05	<0.05
Cr (mg/l)	<0.01	<0.01
Cu (mg/l)	<0.025	<0.025
Fe (mg/l)	<0.1	<0.1
Mg (mg/l)	10.4	10.6
Mn (mg/l)	<0.015	<0.015
Mo (mg/l)	<0.04	<0.04
Na (mg/l)	12.6	8.0
Ni (mg/l)	<0.04	<0.04
Sr (mg/l)	.34	.33
V (mg/l)	<0.05	<0.05

Well	61-86	61-86
Date	03/11/87	05/05/87
Volatiles (ug/l)		
Chloroform	<4	<4
Carbon Tetrachloride	<4	<4
1,1-Dichloroethene	<4	<4
1,2-Dichloroethane	<4	<4
1,1,1-Trichloroethane	<4	<4
1,1,2-Trichloroethane	<4	<4
Trichloroethene	5	<4
Tetrachloroethene	<4	<4
Trans-1,2-Dichloroethene	<4	<4
Metals		
As (mg/l)	<0.01	<0.01
Pb (mg/l)	<0.005	<0.005
Hg (mg/l)	<0.0002	<0.0002
K (mg/l)	<5.0	<5.0
Se (mg/l)	<0.005	<0.005
Tl (mg/l)	<0.01	<0.01
Cs (mg/l)	<0.2	<0.2
Li (mg/l)	-	-
Sb (mg/l)	<0.06	<0.06
Cd (mg/l)	<0.005	<0.005
Zn (mg/l)	<0.02	<0.02
Tests of Data		
Sum of Cations (meq/l)	4.21	4.37
Sum of Anions (meq/l)	3.89	3.56
Cation-Anion Balance	3.90%	10.25%
TDS Calculated (mg/l)	290	280
TDS Calc./Determined	1.24	1.19
Major Ion Water Type		
Ca	67%	72%
Mg	20%	20%
Na+K	13%	8%
Cl	7%	3%
SO4	19%	12%
HCO3+CO3	72%	81%

Well	62-86	62-86
Date	04/10/87	04/30/87
Cl (mg/l)	28.0	26.9
NO3 as N (mg/l)	2.30	2.60
SO4 (mg/l)	60.0	90.0
TDS (mg/l)	274	286
HCO3 (mg/l)	67.5	124
CN (ug/ml)	<1.0	<1.0
Oil & Grease (mg/l)	-	-
Cr+6 (mg/l)	-	-
Radiochemistry		
Gross Alpha (pCi/l)	36+/-27	30+/-12
Gross Beta (pCi/l)	3+/-9	8+/-37
U-234 (pCi/l)	1.5+/-1.6	5.5+/-1.3
U-235 (pCi/l)	(2.5+/-6.0)x10-1	(8.9+/-4.7)x10-1
U-238 (pCi/l)	2.1+/-1.6	3.9+/-1.1
Sr-90 (pCi/l)	<0.6	<0.6
Pu-239 (pCi/l	(3.1+/-9.5)x10-1	0.2+/-1.2
Am-241 (pCi/l)	0.0+/-0.6	(0.0+/-7.7)x10-1
Tritium (pCi/l)	<1.1x10+2	<1.1x10+2
Cs-137 (pCi/l)	-	
Metals		
Ag (mg/l)	<0.01	<0.01
Al (mg/l)	<0.2	<0.2
Ba (mg/l)	<0.2	<0.2
Be (mg/l)	<0.005	<0.005
Ca (mg/l)	37.1	32.5
Co (mg/l)	<0.05	<0.05
Cr (mg/l)	.013	<0.010
Cu (mg/l)	<0.025	<0.025
Fe (mg/l)	<0.1	<0.1
Mg (mg/l)	<5.0	<5.0
Mn (mg/l)	<0.015	<0.015
Mo (mg/l)	<0.04	<0.04
Na (mg/l)	53.5	58.6
Ni (mg/l)	<0.04	<0.04
Sr (mg/l)	.41	.38
V (mg/l)	<0.05	<0.05

Well	62-86	62-86
Date	04/10/87	04/30/87
Volatiles (ug/l)		
Chloroform	<4	<4
Carbon Tetrachloride	<4	<4
1,1-Dichloroethene	<4	<4
1,2-Dichloroethane	<4	<4
1,1,1-Trichloroethane	<4	<4
1,1,2-Trichloroethane	<4	<4
Trichloroethene	<4	<4
Tetrachloroethene	<4	<4
Trans-1,2-Dichloroethene	<4	<4
Metals		
As (mg/l)	<0.01	<0.01
Pb (mg/l)	<0.005	<0.005
Hg (mg/l)	<0.0002	<0.0002
K (mg/l)	13	10
Se (mg/l)	.057	.044
Tl (mg/l)	<0.01	<0.01
Cs (mg/l)	<0.2	<0.2
Li (mg/l)	-	-
Sb (mg/l)	<0.06	<0.06
Cd (mg/l)	<0.005	<0.005
Zn (mg/l)	.05	<0.02
Tests of Data		
Sum of Cations (meq/l)	4.51	4.43
Sum of Anions (meq/l)	3.31	4.85
Cation-Anion Balance	15.36%	-4.57%
TDS Calculated (mg/l)	269	354
TDS Calc./Determined	.98	1.24
Major Ion Water Type		
Ca	41%	37%
Mg	0%	0%
Na+K	59%	63%
Cl	24%	16%
SO4	38%	39%
HCO3+CO3	33%	42%

Well	64-86	68-86	69-86
Date	04/29/87	04/29/87	04/29/87
Cl (mg/l)	38.0	18.0	114
NO3 as N (mg/l)	1.28	.50	2.30
SO4 (mg/l)	168	94.0	270
TDS (mg/l)	438	166	1017
HCO3 (mg/l)	162	56.8	385
CN (ug/ml)	<1.0	<1.0	<1.0
Oil & Grease (mg/l)	-	-	-
Cr+6 (mg/l)	-	-	-
Radiochemistry			
Gross Alpha (pCi/l)	5+/-14	26+/-14	40+/-7
Gross Beta (pCi/l)	-8+/-2	42+/-12	49+/-75
U-234 (pCi/l)	2.2+/-0.9	4.8+/-2.1	(1.2+/-0.2)x10+1
U-235 (pCi/l)	(2.7+/-3.0)x10-1	(6.0+/-6.8)x10-1	(8.0+/-5.6)x10-1
U-238 (pCi/l)	2.4+/-1.0	5.6+/-2.2	(3.3+/-0.5)x10+1
Sr-90 (pCi/l)	<0.6	4.59	.83
Pu-239 (pCi/l	(6.3+/-9.8)x10-1	(0.0+/-6.5)x10-1	0.3+/-2.0
Am-241 (pCi/l)	(5.5+/-7.8)x10-1	3.2+/-2.7	(4.0+/-5.6)x10-1
Tritium (pCi/l)	<1.1x10+2	<1.1x10+2	3x10+2
Cs-137 (pCi/l)	-	-	
Metals			
Ag (mg/l)	<0.01	<0.01	<0.01
Al (mg/l)	<0.2	<0.2	<0.2
Ba (mg/l)	<0.2	<0.2	<0.2
Be (mg/l)	<0.005	<0.005	<0.005
Ca (mg/l)	52.2	14.1	148
Co (mg/l)	<0.05	<0.05	<0.05
Cr (mg/l)	<0.01	<0.01	<0.01
Cu (mg/l)	<0.025	<0.025	<0.025
Fe (mg/l)	<0.1	.10	<0.1
Mg (mg/l)	16.1	<5.0	41.1
Mn (mg/l)	.28	.15	.027
Mo (mg/l)	<0.04	<0.04	<0.04
Na (mg/l)	88.5	20.5	143
Ni (mg/l)	.44	<0.04	<0.04
Sr (mg/l)	.42	<0.20	1.15
V (mg/l)	<0.05	<0.05	<0.05

Well	64-86	68-86	69-86
Date	04/29/87	04/29/87	04/29/87
Volatiles (ug/l)			
Chloroform	<4	<4	<4
Carbon Tetrachloride	<4	<4	<4
1,1-Dichloroethene	<4	<4	<4
1,2-Dichloroethane	<4	<4	<4
1,1,1-Trichloroethane	<4	<4	<4
1,1,2-Trichloroethane	<4	<4	<4
Trichloroethene	<4	<4	<4
Tetrachloroethene	<4	<4	<4
Trans-1,2-Dichloroethene	<4	<4	<4
Metals			
As (mg/l)	<0.01	<0.01	<0.01
Pb (mg/l)	<0.005	<0.005	<0.005
Hg (mg/l)	<0.0002	<0.0002	<0.0002
K (mg/l)	<5.0	<5.0	<5.0
Se (mg/l)	<0.005	<0.005	.242
Tl (mg/l)	<0.01	<0.01	<0.01
Cs (mg/l)	<0.2	<0.2	<0.2
Li (mg/l)	-	-	-
Sb (mg/l)	<0.06	<0.06	<0.06
Cd (mg/l)	<0.005	.007	<0.005
Zn (mg/l)	.02	.03	<0.02
	0		
Tests of Data			
Sum of Cations (meq/l)	7.78	1.60	16.99
Sum of Anions (meq/l)	7.32	3.43	15.31
Cation-Anion Balance	3.06%	-36.53%	5.19%
TDS Calculated (mg/l)	514	206	1070
TDS Calc./Determined	1.17	1.24	1.05
Major Ion Water Type			
Ca	33%	44%	43%
Mg	17%	0%	20%
Na+K	49%	56%	37%
Cl	15%	15%	21%
SO4	48%	57%	37%
HCO3+CO3	36%	27%	41%

overlying approximately 10 feet of clayey sand (contaminated soil), which is in turn underlain by natural sandy clay and clayey sand with caliche (BH10-87). Bedrock is claystone at a depth of 20 feet below ground in BH10-87.

Ground water flows generally to the south away from SWMUs 104 and 130 in the sandy clay and clayey sand colluvium. Flow is toward the three well cluster (59-86BR, 69-86, and 8-87BR). The cluster penetrates one of the gravel layers at the base of the colluvium, but the gravel does not extend up to SWMU 130 (BH13-87 and BH10-87). The wells in the three well cluster are free of volatile organics (Table 4-3); however, radionuclide ground-water contamination appears to exist at all three wells. At the shallow well 69-86, Pu, Am, and U^{238} occurred at 0.3, 0.4 and 33 pCi/l, respectively. At bedrock well 59-86, Pu was observed at 1.3 pCi/l but was undetected in a previously taken sample (see Table 4-2). At bedrock well 8-87BR, Pu was 2.1 pCi/l; however, other radionuclides were conspicuously absent. Strontium concentrations apparently increase with depth in wells 69-86, 59-86BR and 8-87-BR (0.3, 1.2 and 2.3 mg/l, respectively). The bedrock concentrations are above apparent background levels, but the significance of this finding is unknown.

Although bedrock contamination in the vicinity of these SWMUs is uncertain because of conflicting chemical data, the alluvial ground water may be contaminated with radionuclides. This would suggest SWMU 130 as opposed to SWMU 104 as the likely source considering the nature and size of contamination at SWMU 130. Further investigation of both alluvial and bedrock ground-water quality is necessary to confirm these conclusions.

Table 4-3. Volatile Organic Concentrations in Ground Water

Well	Date	TCE	PCE	DCE	TCA	DCA	CCl4	CHCl3
9-74	04/18/85	6400	2800	130	260	<1	<1	<1
	03/20/85	3300	2800	1300	4800	<1	<1	<1
	08/--/86	11000	4800	7200	14000	38	-	5
	04/--/87	20000	6400	12400	13800	75	<4	<4
10-74	04/18/85	950	41	90	<1	4500	10	<1
1-82	04/17/85	7	<1	<1	<1	<1	<1	<1
58-86	08/--/86	dry						
59-86	08/--/86	<1	<1	<1	<1	<1	<1	<1
	04/09/87	<4	<4	<4	<4	<4	<4	<4
	04/30/87	<4	<4	<4	<4	<4	<4	<4
61-86	08/--/86	-	-	-	-	-	-	-
	03/11/87	5	<4	<4	<4	<4	<4	<4
	05/05/87	<4	<4	<4	<4	<4	<4	<4
62-86	08/--/86	<1	<1	<1	<1	<1	<1	<1
	04/10/87	<4	<4	<4	<4	<4	<4	<4
	04/30/87	<4	<4	<4	<4	<4	<4	<4
63-86	08/--/86	dry						
64-86	08/--/86	dry						
	04/29/87	<4	<4	<4	<4	<4	<4	<4
68-86	08/--/86	<1	<1	<1	<1	<1	<1	<1
	04/29/87	<4	<4	<4	<4	<4	<4	<4
69-86	08/--/86	<1	<1	<1	<1	<1	<1	<1
	04/29/87	<4	<4	<4	<4	<4	<4	<4
2-87	05/29/87	-	-	-	-	-	-	-
3-87BR	06/16/87	<4	<4	<4	<4	<4	<4	<4
4-87	05/20/87	525	84	8	<4	32	5	<4
5-87BR	06/12/87	<4	<4	<4	<4	6	<4	<4
8-87BR	06/15/87	<4	<4	<4	<4	<4	<4	<4

Notes:

All units are micrograms per liter (ug/l)
TCE = Trichloroethene
PCE = Tetrachloroethene
DCE = 1,1-Dichloroethene
TCA = 1,1,1-Trichloroethane
DCA = 1,2-Dichloroethane
CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform

4.4.3 Solid Waste Management Unit 119

SWMU 119 consists of two solvent storage areas north of the plant security area (perimeter road). The west area (119.1) is well defined by the storage pad and manufacturing debris which can still be seen. The east area (119.2) is defined by soil gas data.

The west area is underlain by a layer of sandy clay colluvium that is very thin beneath the pad but increases in thickness in the downslope direction (2.2 feet in BH12-87, 6.3 feet at 7-87BRA, and 10 feet at 5-87BR). In addition, there is a 2.2 feet thick gravel zone in 5-87BR immediately overlying the claystone bedrock. The gravel could be connected with the gravel in the colluvium in well 4-87. Bedrock immediately beneath the colluvium consists of claystone. Although 7-87BRA encountered sandstone at a depth of 48.6-51.0 (beneath 23 feet of claystone), the sandstone was apparently dry. First saturated bedrock occurs in a fractured claystone and sandstone horizon at about 41.5 to 51.3 feet below ground (5-87BR). Ground water in this zone is under unconfined conditions.

Ground water from beneath the west area flows downslope to the south in the colluvium with some portion of the water entering the bedrock. Wells 9-74 (mostly a colluvial well with a total depth of 19 feet) and 4-87 both contain volatile organics, probably originating from the west area of the unit. The volatile organics were 1,1 dichloroethene (12,400 ug/l in 9-74 and 8 ug/l in 4-87), 1,2 dichloroethane (75 ug/l in 9-74 and 32 ug/l in 4-87), 1,1,1-trichloroethane (13,800 ug/l in 9-74 and <4 ug/l in 4-87), trichloroethene (20,000 ug/l in 9-74 and 525 ug/l in 4-87) and tetrachloroethene (6,400 ug/l in 9-74 and 84 ug/l in 4-87). Well 9-74 also has elevated Pu (.55 pCi/l) and Am (6.6 pCi/l) concentrations but these radionuclides are absent at 4-87. Strontium

concentrations are above background in all of the wells (1.96 mg/l in 9-74, 1.3 mg/l in 4-87, and 2.3 mg/l in 5-87BR).

A very low concentration of 1,2-dichloroethane was detected in the bedrock at SWMU/ 119.1 (6 ug/l in well 5-87BR). Because the concentration is so close to the detection limit, continued monitoring at well 5-87BR is required to evaluate the potential for bedrock contamination from the west area of the unit.

The east area of the unit (119.2) has been located in the vicinity of BH16-87 and BH17-87, based on soil gas results and chemical analyses of solids from the borings. It appears likely that any ground-water contamination that may be associated with the eastern area flows to the south-west in the vicinity of wells 1-82, 2-82 and 6-87. Soil gas data imply flow to the south-east in the vicinity of wells 62-86BR and 63-86; however, the soils are unsaturated at 63-86 and volatile organics have not been detected in 62-86BR. Ground water does not flow south through the location of 6-87A as this area was dry. Analytical results from 6-87 must be evaluated before the quality of water in the vicinity of the eastern unit can be determined.

4.5 CONCLUSIONS

The ground-water degradation appears limited to the presence of volatile organic compounds and elevated plutonium and americium. With the exception of strontium and major cations, metal concentrations are generally non-detectable or are very low. Strontium concentrations appear elevated relative to levels found in surface water and alluvial ground water west of the Plant.

Three areas at the 881 Hillside appear to have caused this ground-water degradation:

5.0 SURFACE WATER

5.1 SURFACE WATER

Woman Creek is an eastward flowing ephemeral stream located just south of the 881 Hillside (Plate 5-1). The stream drains southern portions of the Rocky Flats Plant site, including the 881 Hillside. Along Woman Creek, two retention ponds and associated diversion structures control surface water discharge from the site in order to limit the potential for release of poor quality water. The retention ponds, designated as C-1 and C-2, are located southeast of the 881 Hillside. Pond C-1 receives stream flow from Woman Creek. This flow is diverted around pond C-2 into the Woman Creek channel downstream. Pond C-2 is offset from Woman Creek and receives surface runoff from the South Interceptor Ditch that traverses the southern portion of the plant site (at the base of the 881 Hillside). The South Interceptor Ditch isolates runoff from the south side of the plant (including the 881 Hillside) from Woman Creek. The ditch extends from the old landfill to Pond C-2, and Woman Creek is diverted around Pond C-2 by a diversion structure just upstream of the pond. Water in Pond C-2 is discharged to Woman Creek in accordance with the Plant NPDES permit. The permitted discharge point is designated 007. In addition to NPDES monitoring requirements, the discharge is monitored for plutonium, americium, uranium, and tritium concentrations.

5.1.1 Surface Water Flow

During August 1986, as part of the initial CEARP site investigations, flow rates were measured in all of the site natural drainages and ditches using a portable cut-throat flume and the Parshall flumes used for NPDES monitoring. The results of flow rate measurements for the South Interceptor Ditch and Woman Creek are discussed below. Flow rates were not measured during the May 1987 surface water sampling.

South Interceptor Ditch

There was intermittent flow in the interceptor ditch in late August 1986. Six stations have been established along the ditch, and the only measurable flow was found at SW-31 (5.5 gpm), near the 881 Hillside. Stagnant water was encountered at SW-36, but flow was not measurable. The ditch was dry both upstream and downstream of the stations.

Woman Creek

Intermittent flow was found along Woman Creek in August 1986. Flow at the most upstream station (SW-42) was about 2.2 gpm, but there was no flow at the next downstream station (SW-40). There were measurable flows of 6.6 gpm and 7.7 gpm at stations farther downstream (SW-34 and SW-32). SW-34 is on a small tributary to Woman Creek upstream of SW-32, so most of the flow at SW-32 can be attributed to the tributary, particularly since there was no flow in Woman Creek immediately above their confluence. Woman Creek was dry immediately below Pond C-1, was flowing at 2.2 gpm just upstream of the Woman Creek diversion around Pond C-2, and was dry just downstream of the diversion return to the stream channel.

5.1.2 Surface Water Chemistry

This section analyzes the surface water quality available to date, which includes analytical results from samples collected in August 1986 and May 1987. The parameters analyzed are presented in Table 5-1, and the data are presented in Tables 5-2, 5-3, and 5-4. Parameters shown in Tables 5-2 through 5-4 are those where the parameter was detected at all stations over time. The discussions are organized by first describing upstream and then downstream water quality conditions relative to the 881 Hillside for both the South Interceptor Ditch and Woman Creek.

TABLE 5-1

SURFACE WATER ANALYTICAL PARAMETERS

AUGUST 1986

Organics

Hazardous Substance List - Volatiles
Hazardous Substance List - Semi-Volatiles
Hazardous Substance List - Pesticides/PCB

Radionuclides

Gross Alpha
Gross Beta
Uranium 233, 234, and 238
Americium 241
Plutonium 239
Tritium

Metals

Hazardous Substance List - Metals
Cesium
Molybdenum
Strontium

Other Inorganics

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate
Cyanide
Phosphate

MAY 1987

Organics

Chloroform
Carbon Tetrachloride
1,1-Dichloroethene
1,2-Dichloroethane
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Tetrachloroethene
t-1,2-Dichloroethene

Radionuclides

Gross Alpha
Gross Beta
Uranium 233, 234, 235, 238
Americium 241
Plutonium 239
Tritium
Strontium 90
Cesium 137

Metals

Hazardous Substances List - Metals
Lithium
Cesium
Molybdenum
Strontium

Other Inorganics

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate
Cyanide
Phosphate
Oil and Grease
Cr (VI)
Total Suspended Solids
Total Dissolved Solids

TABLE 5-2
SURFACE WATER QUALITY
ORGANICS & RADIONUCLIDES*

SAMPLE I.D.	MeCl	Acetone	TCA	PCE	TCE	GA	GB	Pu	Am	$U^{233+234}$	U^{238}	H^3	Sr^{90}	Cs^{137}
Interceptor Ditch:														
SW-37 (8/86)	8	ND	ND	ND	ND	4	9	.05	.06	1.8	1.8	-130	NA	NA
SW-36 (8/86)	ND	ND	ND	ND	ND	24	17	-.04	.04	3.9	17	90	NA	NA
SW-35 (8/86)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA
SW-35 (5/87)	NA	NA	6	ND	ND	20	11	.57	.13	4.1	14	ND	2.95	.8
SW-31 (8/86)	ND	ND	ND	ND	ND	17	15	-.01	-.02	3.1	10	180	NA	NA
SW-31 (5/87)	NA	NA	ND	ND	ND	77	59	.80	.52	6.0	14	ND	3.43	ND
SW-30 (5/87)	NA	NA	ND	ND	ND	18	13	.45	.8	3.0	13	ND	2.03	ND
SW-27 (8/86)	2(BJ)	8(BJ)	ND	ND	ND	33	37	.10	.10	4.1	6.1	-30	NA	NA
SW-C2 (8/86)	ND	ND	ND	ND	ND	7	3	.01	.01	1.5	2.6	-20	NA	NA
881 Hillside:														
SW-45(5/87)	NA	NA	ND	128	14	13	14	0.0	0.0	6.1	5.0	ND	1.78	ND
SW-44 (5/87)	NA	NA	ND	4	ND	21	59	.31	.70	7.7	8.8	ND	ND	ND
SW-46 (5/87)	NA	NA	ND	ND	ND	-9	-5	.69	.18	8.1	1.2	ND	.65	ND
SW-881HS (5/87)	NA	NA	ND	ND	ND	32	61	.28	.51	2.8	3.0	320	.88	ND
Woman Creek:														
SW-42 (8/86)	1(J)	14(B)	ND	ND	ND	0	3	-.02	.02	.13	.06	80	NA	NA
SW-34 (8/86)	ND	7(BJ)	ND	ND	ND	2	1	.02	-.01	-.06	-.05	100	NA	NA
SW-33 (8/86)	78(B)	ND	ND	ND	ND	0	0	-.04	-.01	-.03	-.20	70	NA	NA
SW-32 (8/86)	ND	ND	ND	ND	ND	4	18	.23	.01	.03	.04	-50	NA	NA
SW-32 (5/87)	NA	NA	ND	ND	ND	8	10	.66	.60	3.4	1.5	ND	3.15	ND
SW-C1 (8/86)	ND	ND	ND	ND	ND	6	5	.08	.03	1.8	1.5	-90	NA	NA
SW-29 (5/87)	NA	NA	ND	ND	ND	0	33	.00	.00	1.2	1.5	110	1.8	ND
SW-28 (8/86)	5(B)	7(BJ)	ND	ND	ND	6	4	-.04	.00	1.2	.87	190	NA	NA

*NOTES:

Abbreviated Compounds are:

- MeCl - Methylene Chloride
- TCA - 1,1,1-Trichloroethane
- PCE - Tetrachloroethene
- TCE - Trichloroethene
- $G\alpha$ - Gross Alpha
- $G\beta$ - Gross Beta
- Pu - Plutonium
- Am - Americium
- $U^{233+234}$ Uranium 233+234
- U^{238} - Uranium 238
- H^{3} - Tritium
- Sr^{90} - Strontium 90
- Cs^{137} - Cesium 137

Units:

- Organics - ug/l = ppb
- Radionuclides - pCi/l

TABLE 5-3

SURFACE WATER QUALITY METALS*

SAMPLE I.D.	Al	Sb	As	Ba	Be	Cs	Cr	Co	Cu	Fe	Mn	Hg	Mo	Ni	Se	Ag	Sr	V	Zn
Interceptor Ditch:																			
SW-37 (8/86)	ND	ND	6.0	ND	ND	ND	ND	ND	ND	180	21	ND	ND	ND	ND	ND	110	ND	ND
SW-36 (8/86)	210	ND	ND	ND	90	ND	ND	50	ND	ND	120	4.65	300	ND	ND	ND	420	ND	1000
SW-35 (8/86)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-35 (5/87)	251+	NA	NA	ND	ND	NA	ND	ND	25+	173+	112/ 155+	NA	ND	ND	NA	ND	ND	ND	NA
SW-31 (8/86)	3470	ND	ND	ND	90	ND	ND	ND	40	200	70	ND	ND	ND	ND	ND	380	ND	589
SW-31 (5/87)	13630+	NA	NA	NA	ND	NA	86+	ND	38+	8610+	140+	NA	NA	ND	NA	ND	ND	ND	NA
SW-30 (5/87)	1197+	ND	NA	ND	ND	NA	ND	ND	ND	969+	21+	NA	ND	ND	NA	ND	393/ 407+	ND	NA
SW-27 (8/86)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	420	ND	ND
SW-C2 (8/86)	ND	ND	ND	240	20	ND	21	ND	ND	ND	ND	ND	100	ND	ND	ND	230	ND	ND
881 Hillside:																			
SW-45 (5/87)	ND	NA	NA	ND	ND	NA	ND	ND	ND	231+	ND	NA	ND	43+	NA	ND	ND	ND	NA
SW-44 (5/87)	3767+	NA	NA	ND	7+	NA	43+	ND	33+	256+	55+	NA	ND	ND	NA	ND	ND	ND	NA
SW-46 (5/87)	1131+	NA	NA	ND	ND	NA	ND	ND	ND	213/ 1582+	112+	NA	ND	ND	NA	ND	ND	ND	NA
SW-881HS (5/87)	100593+	NA	NA	620+	ND	NA	80+	ND	ND	64175+	734+	NA	ND	49+	NA	ND	ND	185+	NA
Woman Creek:																			
SW-42 (8/86)	540	37	ND	ND	ND	170	ND	ND	ND	130	ND	.5	680	82	8.8	22	ND	450	16
SW-34 (8/86)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170	ND	ND
SW-33 (8/86)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-32 (8/86)	ND	ND	ND	ND	90	ND	ND	ND	90	ND	ND	ND	300	ND	ND	ND	230	ND	ND
SW-32 (5/87)	281+	NA	NA	ND	ND	NA	ND	ND	ND	392+	295+	NA	NA	ND	NA	ND	ND	ND	NA
SW-C1 (8/86)	ND	ND	ND	240	20	ND	21	ND	ND	ND	ND	ND	100	ND	ND	ND	230	ND	ND
SW-29 (5/87)	358+	ND	NA	ND	ND	NA	ND	ND	ND	704+	51/ 106+	ND	ND	ND	NA	ND	239/ 242+	ND	NA
SW-28 (8/86)	ND	ND	ND	ND	ND	ND	ND	ND	ND	50	54	ND	ND	ND	ND	ND	460	ND	22

*Notes:

Abbreviated Compounds are:

- Al - Aluminum
- Sb - Antimony
- As - Arsenic
- Ba - Barium
- Be - Beryllium
- Cs - Cesium
- Cr - Chromium
- Co - Cobalt
- Cu - Copper
- Fe - Iron
- Mn - Manganese
- Hg - Mercury
- Mo - Molybdenum
- Ni - Nickel
- Se - Selenium
- Ag - Silver
- Sr - Strontium
- V - Vanadium
- Zn - Zinc

Units:

- ug/l = ppb
- + indicates a total concentration; data are otherwise soluble concentrations

TABLE 5-4

SURFACE WATER QUALITY
OTHER INORGANICS*

SAMPLE I.D.	Ca	Mg	K	Na	HCO_3	CO_3	Cl^-	CN	PO_4	SO_4	NO_3
Interceptor Ditch:											
SW-37 (8/86)	43	2	9	10	6	110	4	ND	7	6	ND
SW-36 (8/86)	123	10	ND	15	4	200	30	ND	ND	60	20
SW-35 (8/86)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SW-35 (5/87)	60/60+	11/12+	NA	24/22+	144	NA	23	ND	NA	49	2
SW-31 (8/86)	103	10	ND	19	ND	200	400	ND	ND	50	8
SW-31 (5/87)	60/69+	14/16+	NA	37/36+	143	NA	38	ND	NA	53	2.1
SW-30 (5/87)	66/62+	15/16+	NA	36/33+	165	NA	34	ND	NA	68	1.3
SW-27 (8/86)	58	19	4	45	100	200	50	ND	5	80	ND
SW-C2 (8/86)	21	10	ND	34	ND	100	30	ND	20	70	ND
881 Hillside:											
SW-45 (5/87)	95/87+	19/20+	NA	52/45+	216	NA	74	ND	NA	44	9
SW-44 (5/87)	1.8/68+	15/17+	NA	41/37+	168	ND	48	ND	ND	64	4
SW-46 (5/87)	29/24+	20/6+	NA	22/20+	87	NA	11	ND	NA	27	ND
SW-881HS (5/87)	163+	42+	NA	89+	318	NA	16	ND	NA	95	ND
Woman Creek:											
SW-42 (8/86)	7	1	.4	4	10	20	2	.0016	.92	ND	ND
SW-34 (8/86)	65	7	1	3	6	100	16	ND	2	20	ND
SW-33 (8/86)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SW-32 (8/86)	67	2	ND	8	4	120	10	ND	2	20	ND
SW-32 (5/87)	48/45+	9/9+	NA	22/23+	160	NA	11	ND	NA	20	ND
SW-C1 (8/86)	21	10	ND	34	4	100	20	ND	2	40	ND
SW-29 (5/87)	47+	ND	NA	ND	160	NA	11.9	ND	NA	8	ND
SW-28 (8/86)	90	17	8	42	7	200	40	ND	20	90	ND

*Notes:

Abbreviated compounds are:

- Ca - Calcium
- Mg - Magnesium
- K - Potassium
- Na - Sodium
- HCO_3 - Carbonate
- CO_3 - Bicarbonate
- Cl - Chloride
- CN - Cyanide
- PO_4 - Phosphate
- SO_4 - Sulfate
- NO_3 - Nitrate

Units:

- mg/l

South Interceptor Ditch

The furthest upstream surface water station that had flow during the August 1986 sampling activities was SW-37. This station is a discharging culvert, the flow originating from surface water runoff and groundwater from footing drains around Building 460. With the exception of methylene chloride at 8 ppb, HSL organics were not present above detection limits. As methylene chloride is a common lab contaminant, and the measured concentration was low, it is unlikely that methylene chloride was actually present in the surface water. Plutonium (Pu), Americium (Am), Uranium (U)$^{233 + 234}$ and U ^{238} were present at .05, .06, 1.8, and 1.8 pCi/l, respectively. Tritium was non-detectable. Nitrate was also not detected. Trace metal concentrations were generally non-detectable. Measurable trace metal concentrations included arsenic (6 ppb), iron (180 ppb), manganese (21 ppb), and strontium (110 ppb). Major ion concentrations were low, with calcium (43 mg/l) and carbonate (110 mg/l) dominating. SW-37 was not sampled in May 1987.

At station SW-36 downstream of the old landfill, but upstream of the 881 Hillside, radionuclides and metals were elevated relative to SW-37. Of the radionuclides, $U^{233 + 234}$ (3.9 pCi/l), and U^{238} (17 pCi/l) were elevated. Metal concentrations that were elevated relative to SW-37 include beryllium (90 ppb), cobalt (50 ppb), manganese (120 ppb), mercury (4.65 ppb), molybdenum (300 ppb), strontium (420 ppb), and zinc (1000 ppb). The dominant major ions were calcium (123 mg/l) and carbonate (200 mg/l), which also occurred at somewhat higher concentrations than at SW-37. There was an order of magnitude increase in chloride (30 mg/l) and sulfate (60 mg/l), and nitrate was present at 20 mg/l. HSL organics were not present above detection limits. The elevated uranium, trace metal, and major ion concentrations may reflect a release from the old landfill (or other source).

SW-35 is located further downstream of SW-36 but is also upstream of the 881 Hillside. Data for SW-35 (May 1987) show an increase in radionuclide concentration over that observed at SW-36 (August 1986). Plutonium, americium, uranium$^{233 + 234}$, and uranium^{238} were 0.57, 0.13, 4.1, and 14 pCi/l, respectively. Tritium was non-detectable. Strontium 90 and cesium 137 were measured at 2.95 and 0.8 pCi/l, respectively. Strontium 90 and cesium 137 were not measured during the previous investigation; however, comparison to data at other stations indicates these levels do not constitute a contaminant release. Trace metal concentrations were either not detectable or at low values. Major ion concentrations were similar to that observed at SW-36. 1,1,1-trichloroethane was measured at 6 ppb; however, since this value is at the detection limit, the significance of this value cannot be determined without further sampling. The data may indicate a release of radionuclides except Sr^{90} and Cs^{137} from an unidentified source downstream of the old landfill.

There are three stations located on the 881 Hillside due south of Building 881; SW-45 (a pipe discharging to a skimming pond and presumably draining the footings of Building 881), SW-46 (a pond formed by seepage from the 881 Hillside, west and hydraulically upgradient of the skimming pond, and presumably overflowing to the skimming pond and/or in direct communication via alluvial groundwater), and SW-44 (a pipe discharging directly to the interceptor ditch and presumably draining the skimming pond). Notable chemical characteristics of the discharge at SW-45 are the presence of tetrachloroethene (128 ppb) and trichloroethene (14 ppb), and possibly elevated $U^{233 + 234}$ (6.1 pCi/l), and U^{238} (5.0 pCi/l). The pond (SW-46) had notable Pu (.69 pCi/l), Am (.18 pCi/l), and $U^{233 + 234}$ (8.1 pCi/l). The discharge to the interceptor ditch (SW-44) contained tetrachloroethene (4ppb) and elevated Pu (3.1 pCi/l), Am (.70 pCi/l), $U^{233 + 234}$ (7.7 pCi/l) and U^{238} (8.8 pCi/l), which is consistent with the fact that SW-44 drains

the skimming pond, which in turn receives an input of radionuclides from the SW-46 pond, and organics and radionuclides from SW-45. It appears the tetrachloroethene and trichloroethene volatilized during detention in the skimming pond. The detention time has been estimated at 18 hours.

Water chemistry at SW-31 located southeast of Building 881 and downgradient of the Hillside, and SW-30 located southeast and downgradient of the Hillside, is similar to that observed at SW-35. There is no apparent impact of the SW-44 discharge on the interceptor ditch simply because the water quality upstream of the discharge point is similar to the SW-44 discharge itself. At SW-31, Pu and Am were 0.80 and 0.52 pCi/l, respectively, while at SW-30 they were 0.45 and 0.80 pCi/l. Organics were not detected at either station. There were few changes in major ion or metal concentrations relative to the chemistry at SW-35. However, in May 1987, aluminum was observed at SW-31, and SW-30 to be 13,630, and 1,197 mg/l, respectively. Aluminum was only 251 mg/l at SW-35. As these values represent total concentrations, the increase in aluminum may simply be due to runoff-generated suspended clays.

At SW-27, downstream of the 881 Hillside and located at the entrance to Pond C-2, major ion concentrations were similar to upstream water; however, plutonium and americium concentrations had each dropped to 0.10 pCi/l, and metal concentrations were non-detectable with the exception of strontium at 420 ppb. The strontium value is typical of concentrations observed upstream. The lower plutonium and americium concentrations may be due to dilution or attenuation, and/or simply reflect other temporal changes as the data being compared are for two different times of the year. This station was the only surface water or ground water sampling location where HSL base neutral/acid compounds were present above detection limits. Phenol and 2-

methylphenol occurred at 13 ppb and 24 ppb, respectively. It is difficult to place much significance on this isolated incidence.

Pond C-2 is downstream of the 881 Hillside and receives flow from the Interceptor Ditch. Radionuclide, metal, and major ion concentrations are at levels similar to the furthest upstream station (SW-37) which may reflect dilution, adsorption, and/or precipitation. Barium was a notable exception, occurring at 240 ppb and otherwise non-detected in the Interceptor Ditch. In regard to this observation, barium was detected in a seep on the 881 Hillside (SW-881 HS) which may indicate hydraulic interaction of alluvial groundwater with Pond C-2. However, there is no evidence of the elevated radionuclides at SW-881HS [Pu (0.28 Pci/l) and Am (0.51 pCi/l] in Pond C-2, which implies attenuative mechanisms for these elements. Also, the maximum concentrations of radionuclides reported for NPDES discharge 007 [effluent discharge of C-2 are consistent with this data (Table 5-5)].

In general, it appears the Interceptor Ditch is largely impacted by the old landfill or other unknown and nearby release site, with some additional impacts by the 881 Hillside. Contaminants released of greatest concern are plutonium and americium. However, water quality in Pond C-2 does not appear to be adversely impacted by these releases. HSL organics are not likely present in the Interceptor Ditch as only common lab contaminants were found at low concentrations.

Woman Creek

Station SW-42 is located west and hydraulically upgradient of the entire Plant. In August 1986, HSL organics were not present above detection limits. Metal concentrations worthy of note are cesium (170 ppb), molybdenum (680 ppb), nickel (82 ppb), and vanadium (450 ppb). Strontium was not detected and neither was nitrate. Radionuclide

TABLE 5-5

MAXIMUM CONCENTRATIONS OF PARAMETERS MEASURED AT NPDES DISCHARGE 007 ON POND C-2 FROM 1980-1986

PARAMETER	MAXIMUM CONCENTRATION
NO_3-N	1.3 mg/l
pH	8.5 st. units
Fixed Suspended Solids	20 mg/l
Pu^{239}	0.05 pCi/l
Am^{241}	0.02 pCi/l
$U^{233+234+238}$	8 pCi/l
H^3	300 pCi/l

concentrations were low or non-detectable. Detectable radionuclides include uranium^{233} + ^{234} (0.13 pCi/l), uranium^{238} (0.06 pCi/l), and tritium (80 pCi/l). Major ions were at low concentrations, the dominant cation and anion being calcium and carbonate occurring at 7 mg/l and 20 mg/l, respectively.

August 1986 data for station SW-34 located south of Building 881 on a tributary to Woman Creek indicate no HSL organics present and even lower concentrations of radionuclides than that observed at SW-42. There were no positive values for plutonium or uranium, and americium, and tritium were 0.02, and 100 pCi/l, respectively. Metal concentrations were non-detectable with the exception of strontium at 170 ppb. Major ion concentrations were higher with calcium (65 mg/l) and carbonate (100 mg/l) dominating, and chloride (16 mg/l) and sulfate (20 mg/l) now occurring.

SW-33 is located due south of the 881 Hillside (downgradient) on the main stream channel of Woman Creek. Although there are no data on metals and major ions, radionuclide data indicates non-detectable levels of all radionuclides except tritium (80 pCi/l). Methylene chloride was present in the sample at 78 ppb; however, this compound was also present in the laboratory blank. Other HSL organics were not detected.

At station SW-32 on Woman Creek just downstream of the confluence with the aforementioned tributary, August 1986 data indicate plutonium was 0.23 pCi/l and other radionuclides were typical of upstream concentrations. The May 1987 data also show elevated plutonium (0.66 pCi/l) as well as elevated americium (0.60 pCi/l), and uranium^{233} + ^{234} (3.4 pCi/l). Nitrates and HSL organics were not present above detection limits. Metal and major ion concentrations were similar to upstream conditions. The plutonium (and americium) concentrations observed may be an indicator of a radionuclide release from the 881 Hillside. However, it should be noted that

directly upstream of this station (SW-33 and SW-34) there was no indication of a contaminant release. This casts considerable uncertainty regarding contamination at SW-32, especially in light of there being only one set of chemistry data for this station.

Data from stations SW-C1 (Pond C-1), SW-29, and SW-28, all located downgradient of the 881 Hillside, do not show any indications of a contaminant release from the 881 Hillside impacting Woman Creek. Therefore, it appears that only at SW-32 is there evidence of contamination along Woman Creek. This area should be further investigated.

5.2 SEDIMENTS

Sediment samples were collected during the 1986 field investigation from streams and ditches that traverse the Rocky Flats Plant site. Impacts of the 881 Hillside on Woman Creek stream sediments were evaluated by comparing upstream (background) sediment chemistry to downstream sediment chemistry.

5.2.1 Background Sediment Chemistry

SED-15 was collected in Woman Creek near the west boundary of the facility and is thus representative of background conditions. HSL organic compounds (other than suspected lab contaminants) were not present above detection limits. Major ion concentrations of this sediment sample consisted of calcium (360 ppm), magnesium (300 ppm), phosphate (310 ppm) and potassium (330 ppm). Other cations and anions, including nitrates, were approximately an order of magnitude lower in concentration.

Concentrations of metals and radionuclides were within apparent background values (i.e., typical of values observed at another upstream station on Church Ditch). Plutonium, americium, $U^{233 + 234}$, and U^{238} were present at -0.05, 0.02, 0.38, and 0.36 pCi/g, respectively. Tritium was present at 0.21 pCi/ml.

5.2.2 Downgradient Sediment Chemistry

Downstream samples from the 881 Hillside were collected at stations SED-1 and SED-2, located adjacent to Indiana Street. Metals in SED-1 and SED-2 were in similar concentrations to background values. Major ions were elevated in SED-1 with calcium (1,740 ppm), magnesium (1,080 ppm), potassium (18,600 ppm), phosphate (4,990 ppm), and sulfate (244 ppm) concentrations being above background.

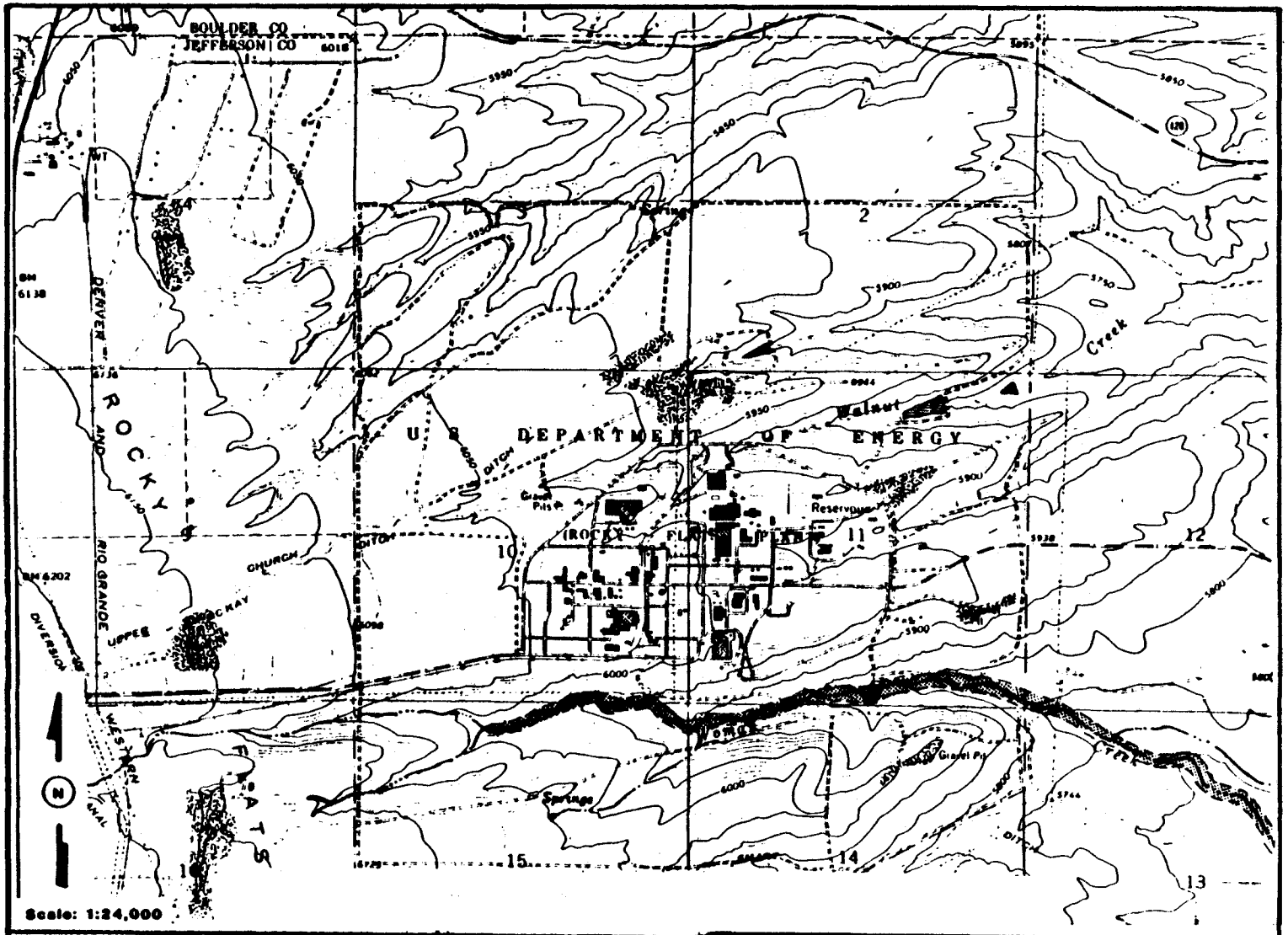
Radionuclide concentrations were elevated above "background" values at each of the downstream sample locations. The respective concentrations of elevated radionuclides at SED-1 and SED-2 include: plutonium (0.03 and 0.08 pCi/g), americium (0.91 and 0.04 pCi/g), $U^{233 + 234}$ (0.51 and 0.79 pCi/g) and U^{238} (0.49 and 0.52 pCi/g). Tritium was also present in a concentration of 0.32 pCi/ml in sample SED-1. With the exception of the americium concentrations, the soil concentrations at SED-2 were higher than at SED-1. SED-2 is located on an ephemeral stream due north of Woman Creek, which drains the East Trenches Area. The elevated concentrations at SED-1 and SED-2 may be indicative of releases from the 881 Hillside and East Trenches, respectively. However, plutonium concentrations are lower than those reported for soils in this vicinity (Rockwell International, 1987) implying that elevated plutonium or other radionuclides in soils downwind of the Plant are simply due to resuspension and settling of contaminated dust from the 903 Pad Area.

5.3 FLOOD POTENTIAL

Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps were obtained for the areas surrounding the Rocky Flats site. These maps exclude the area within Rocky Flats Plant; however, they indicate a narrow 100-year flood plain for

Woman Creek up to the eastern Rocky Flats property boundary. The FEMA map flood plain was extrapolated upstream into the facility along with Woman Creek (Figure 5-1).

A review of topographic maps clearly indicates that the 881 Hillside at Rocky Flats Plant is well above any potential 100-year flood plain. Elevations of SWMUs at the 881 Hillside range from 5944 to 5995 feet above mean sea level. Average stream channel elevations for Woman Creek, below the 881 Hillside, ranges from 5880 due south of SWMU 106 to 5820 at Pond C-1.



EXTENT OF 100-YEAR FLOOD PLAIN

NOT TO SCALE

WESTON
MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 5-1

100-YEAR FLOOD PLAINS IN THE VICINITY OF ROCKY FLATS PLANT

6.0 AIR

Information concerning past practices at the 881 Hillside and data from 1986 and 1987 field investigations indicate that volatile organic compounds and radionuclides are not of concern at the soil surface or in ambient air. Likewise, ambient air monitoring at the Plant indicate no discernable air quality effect from the 1986 field activities. Ambient air data for 1987 have also been evaluated for any effects due to the field activities, and no effects have been found. In order to protect field workers and to verify the above information, surveys for radionuclides and volatile organics were conducted at the 881 Hillside prior to the start of 1987 field activities. Additionally, readings were taken for volatile organics during drilling activities, and all workers and equipment were monitored for radioactivity prior to leaving the 881 Hillside Area.

6.1 PLANT AMBIENT AIR MONITORING

Ambient air monitoring is conducted as a part of the routine environmental monitoring program at the Plant. The air samplers for these monitoring activities are located at various locations on plantsite as well as near the Plant. The ambient air monitoring program is maintained for both radionuclides and conventional air quality parameters.

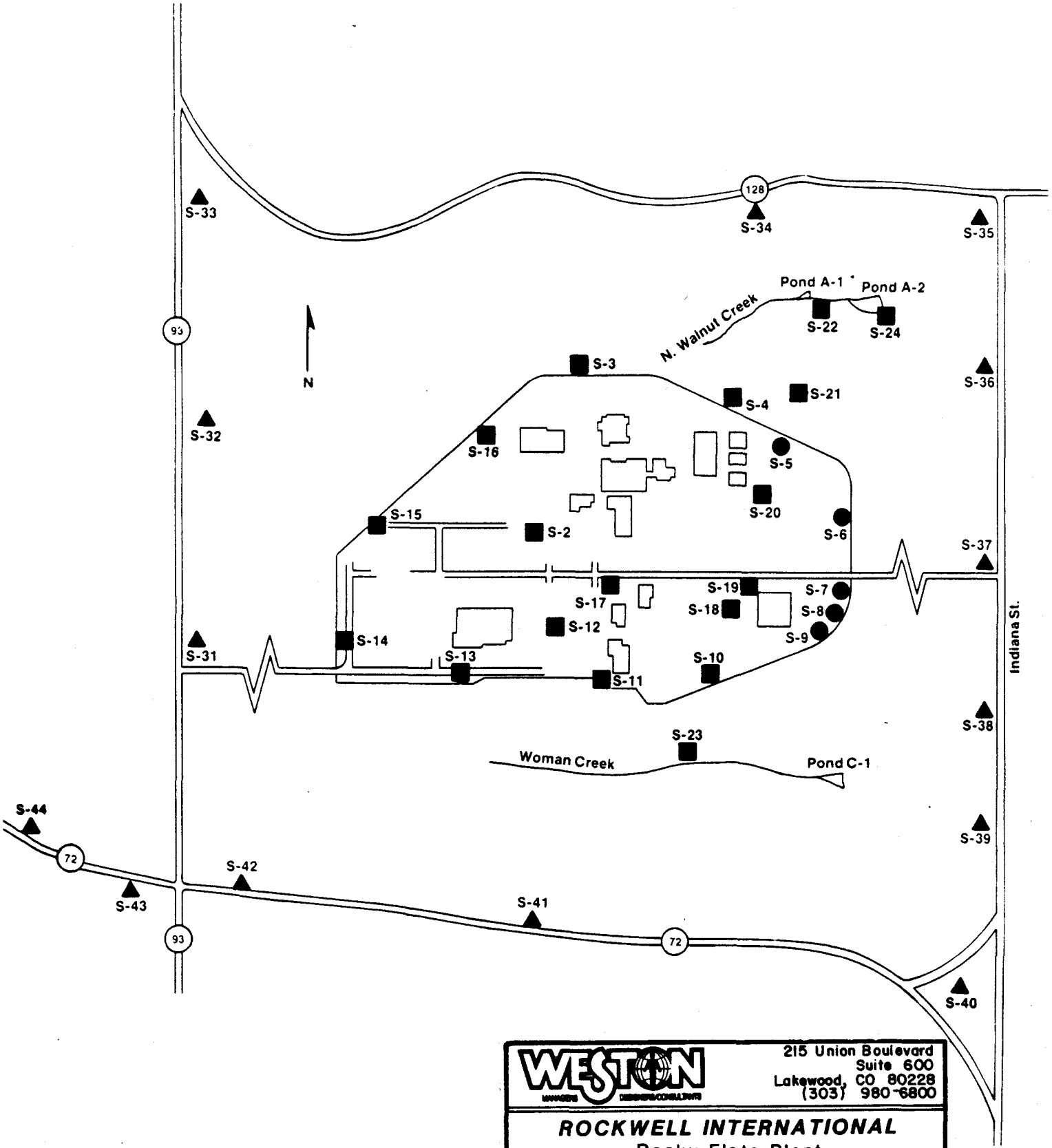
6.1.1 Ambient Air Sampling for Radionuclides

The Plant Radioactive Ambient Air Monitoring Program (RAAMP) is comprised of 51 high-volume particulate air samplers which operate continuously at a volumetric flow rate of approximately 12 liters per second (25cfm). Particulates are collected on a 20 x 25 centimeter (8 x 10 inch) fiberglass filter media. These filters are periodically analyzed for plutonium-239 and plutonium-240. Tests have shown these filters to be 99.42 percent efficient in collecting particulates of 0.01 - 1.0 microns in median

aerodynamic diameter (Rockwell International, 1986f). Of the 51 samplers, 23 are located within or directly adjacent to the Plant security area (onsite samplers), and 14 are located around the DOE property boundary (perimeter samplers). All perimeter samplers are located within two to four miles of the center of the Plant. These locations are shown in Figure 6-1. An additional 14 samplers (community samplers) are located in communities neighboring the Plant as shown in Figure 6-2. The majority of these samplers have been in operation for the last ten years (Rockwell International, 1975-1976, 1977, 1976, 1977, 1978, 1979, 1980, 1981a, 1982a, 1983, 1984a, 1985, 1986g, 1987).

Exposed filters from the 23 onsite samplers are collected biweekly and analyzed individually for total long-lived alpha activity. Any filter exceeding the Plant screening guide of 0.01 picocuries per cubic meter of total long-lived alpha activity is specifically analyzed for plutonium. RAAMP analyses are conducted for long-lived alpha and plutonium activity, only.

Filters from five of the 23 onsite samplers are analyzed separately for plutonium biweekly. These five samplers (S-5, S-6, S-7, S-8, S-9) have historically shown the highest plutonium concentrations of all onsite samplers, probably due to their proximity to the 903 Pad Area and the Solar Ponds. Since their installation, all onsite samplers have recorded mean annual plutonium concentrations less than seven percent of the Derived Concentration Guide (DCG) for inhalation of class W plutonium by members of the public (0.02 picocuries per cubic meter). The choice of a Class W lung clearance category was based on a conservative estimate (maximized total dose equivalent) of total committed dose equivalent due to inhalation of plutonium. It is expected that most plutonium released will be of Class Y lung clearance category, with a consequent lesser dose. Since 1977, mean annual plutonium levels at all onsite samplers have been less than 3 percent of the DCG. A study of recent Plant data has shown no detectable trends



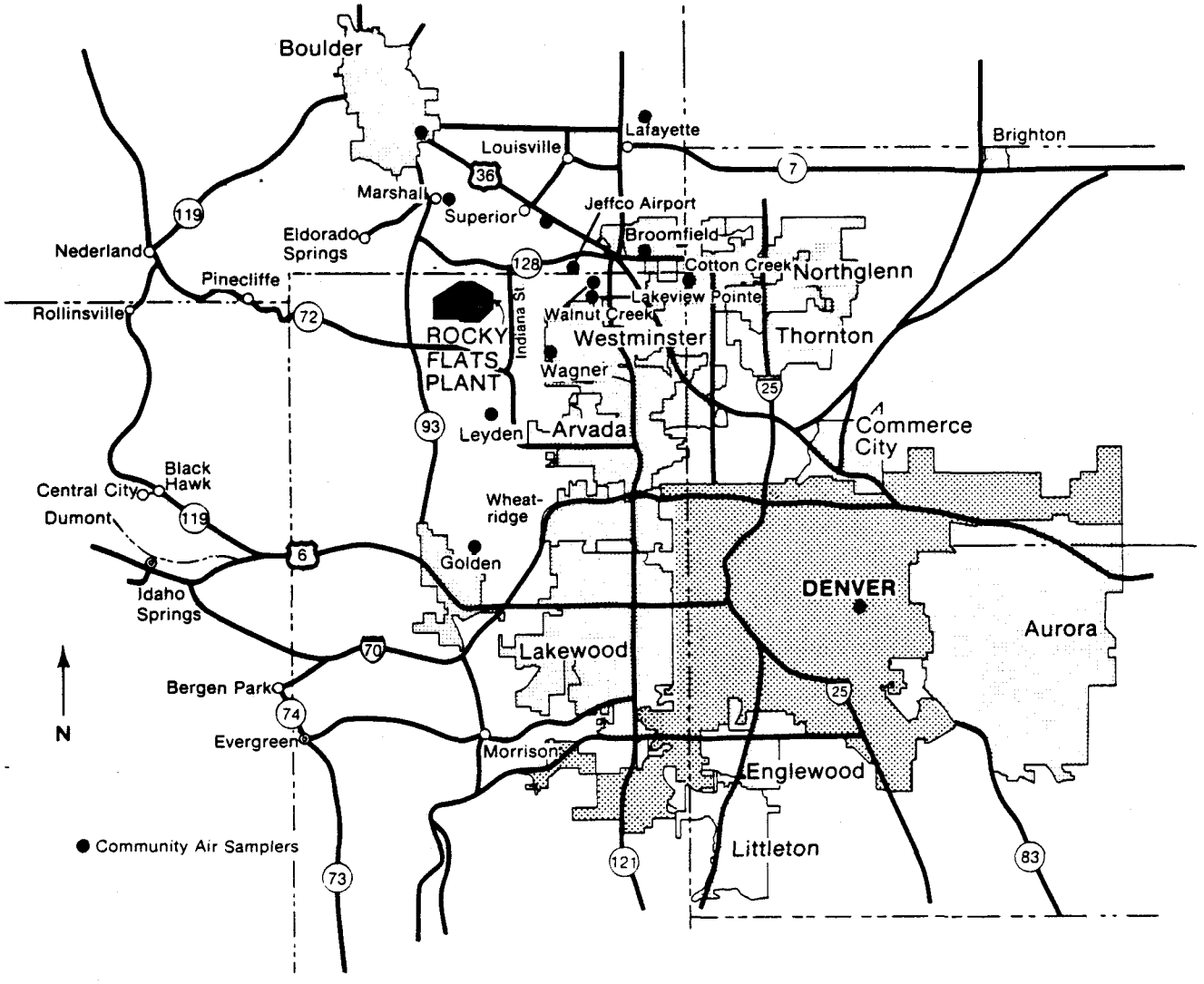
WESTON
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 6-1

LOCATION OF ONSITE AND PLANT PERIMETER AMBIENT AIR SAMPLERS

(Portions of Figure are not to scale)



● OFF-SITE COMMUNITY AMBIENT AIR SAMPLERS

WESTON MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 6-2

LOCATION OF OFF-SITE COMMUNITY AMBIENT AIR SAMPLES

(Rockwell International, 1975, 1976, 1977, 1976, 1977, 1978, 1979, 1980, 1981a, 1982a, 1983, 1984a, 1985, 1986g, 1987).

All perimeter and community ambient air samplers have recorded annual mean plutonium concentrations below 0.4 percent of the DCG value since their installation. These sampler results approximate the magnitude of the minimum detectable activity for plutonium concentration in air samples for the Plant Environmental Laboratories.

Results of the Plant RAAMP samples are presented in the "Monthly Environmental Monitoring Report" and summarized on a yearly basis in the "Annual Environmental Monitoring Report." Both of these reports are published by Rockwell International and distributed to regulatory agencies and nearby communities.

To date, no data trends or anomolous values were recorded at samplers near the 881 Hillside Area during the 1986 or the 1987 field activities. It can be concluded that the 881 Hillside Area remedial investigation field activities are not contributing significantly to plutonium movement.

6.1.2 Routine Nonradioactive Ambient Air Monitoring

Monitoring of ambient air at the Plant also includes the following: total suspended particulates (TSP), ozone, sulfur dioxide, carbon monoxide, nitrogen dioxide, and lead. These six parameters are criteria pollutants regulated by the EPA and the State of Colorado through the Clean Air Act (CAA), and are monitored at a single monitoring location (near the east entrance to the Plant) throughout the year. This location is an open area near a traffic zone, generally downwind from plant buildings, and is near the 881 Hillside. Proposed EPA regulatory requirements may require selected sampling of particulates in the inhalable and respirable particle size range and TSP sampling may be required as well for tracking 24-hour secondary standards. In

anticipation of these requirements, the Plant co-located a Wedding PM-10 type sampler in 1986. The Wedding PM-10 sampler is designed to meet the EPA proposed standard at a flow rate of 40 cfm. Limited co-sampling with the PM-10 sampler and the TSP sampler was conducted in 1986. Routine PM-10 sampling will be reinstated in 1987.

In general, the values for all of the analyzed conventional pollutants (TSP, lead, sulfur dioxide, carbon monoxide, nitrogen dioxide, and ozone) were measured at 30 percent or less of any applicable limits or guidelines, with the exception of TSP and ozone. The highest TSP value for 1986 (a 24-hour sample) was 156 micrograms per cubic meter, which is 60 percent of the 24-hour National Ambient Air Quality Standard (NAAQS) primary standard of 260 micrograms per cubic meter. The annual TSP geometric mean value for 1986 was 48 micrograms per cubic meter, which is 64 percent of the NAAQS primary annual geometric mean standard of 75 micrograms per cubic meter. The geometric mean is defined as the antilog of the average of the logarithms of the data values. The maximum 1-hour 1986 ozone value was 0.181 ppm, which is 151 percent of the NAAQS primary one-hour standard fo 0.120 ppm. The second highest 1-hour ozone value was 0.172 ppm. These ozone values are consistent with levels measured in the general Denver metropolitan area during high pollution episodes. Given the nature of the pollutants expected to be encountered at the 881 Hillside, none of the conventional air pollutant parameters were expected to be affected by the 881 Hillside activities. To date, no effect has been detected.

6.1.3 Special Dust Resuspension Studies

Since low amounts of above-background plutonium exist in the ambient air and soil at the Plant, DOE studied dust resuspension at the Plant. This research has been conducted to determine and further define the quality and quantity of blowing dusts. This research was specifically conducted in relation to the plutonium contamination at

the 903 Pad. Initially, a laser beam was used in the form of a wide ribbon skimming the soil surface to study dust resuspension from bare soil (Rockwell International, 1981b). This study determined that resuspension of dust from bare Rocky Flats soil started at 30-35 mph wind speed, but that the total mass resuspended was very low and could not account for all of the plutonium dispersal. A saltating particle counter was then placed into the surface of the soil to study saltating soil particles (Rockwell Internatinal, 1981b). The counts of saltating particles were lower than predicted by classical saltation theory. A Bagnold catcher was then used, and also confirmed that classical saltation as developed in the 1930's did not apply to soils at the Plant (Rockwell International, 1982b). A wind directional air sampler and a control sampler were then used to study dust resuspension for a period of seven years. Only two instances were identified in this period in which dust resuspension was clearly affected by wind speed. These instances were major wind storms of 100 and 130 mph winds. The high winds apparently broke up the soil crust and resulted in dust resuspension increases of one and two orders of magnitude, respectively (Rockwell International, 1984b).

Of all airborne plutonium activity collected during these studies, it was found that 70 percent of the airborne plutonium activity was on particles greater than 15 microns in size. The airborne activity on respirable particles, 3 microns in median aerodynamic diameter, was at fallout levels. These respirable particles are described as a cumulative lognormal function with a median value of 3.0 microns, typically respirable particles vary in aerodynamic diameter from 0.1-10.0 microns. It was also found that approximately 40% of the mass in particles greater than 15 microns in size was organic, presumably vegetative litter. This indicated that the major source of dust was not areas of bare soil (about 5% of the total), but rather areas of prairie grass. A portable wind tunnel study found that quantifiable amounts of fines (<3 micron particles) were

resuspended, regardless of air velocity (Rockwell International, 1981c and 1983b. Grass was found to release plutonium down to wind speeds of at least 22 mph, whereas bare, rather crusty soil only released plutonium particles at wind speeds of 40 mph or more. Rain splash also releases small amounts of plutonium from soil (Rockwell International, 1986f).

In summary, all research studies demonstrated that the amounts of resuspended dust at the Rocky Flats Plant are much lower than predicted by classical saltation theory. No consistent theory of dust resuspension at the Plant has been adequately researched. Furthermore, 70 percent of the plutonium carrying dust particles are of a non-inhalable size range (greater than 15 microns in diameter). Resuspended dust from the 903 Pad area does not contain above fallout levels of plutonium in the respirable size range. The dust resuspension studies demonstrate that the potential for exposure to dusts contaminated by either radioactive or hazardous materials is low.

6.2 REMEDIAL INVESTIGATION AIR SAMPLING RESULTS

6.2.1 Radiometric Survey

A radiometric survey of the entire Plant security area was completed in 1984 using a Field Instrument for Detecting Low Energy Radiation (FIDLER). Operations of the FIDLER probe gamma survey instrument are reviewed in Case, et al. (1971). This survey also included limited areas outside the Plant security area. The 881 Hillside area within the security fence was surveyed as a part of the above study.

The survey results indicated background levels of radiation with the exception of four small (approximately 11 square feet each) areas with gamma activity above background levels. These four areas are physically marked, and field personnel have been directed to avoid these areas. When soil is disturbed at depths less than 12 inches,

Tyvek coveralls, gloves, and shoe covers are required for personnel. Whenever soil is disturbed to a depth greater than 12 inches, respiratory protection (half-mask particulate), Saranex coveralls, gloves, and shoe covers are required for personnel. Equipment and personnel are always monitored for radioactive contamination before exiting the area. To date, no contamination of field workers upon exiting the 881 Hillside Area has been detected.

The above discussion indicates that radioactive contamination of air and air particulates is not a problem at the 881 Hillside Area.

6.2.2 Volatile Organic Compound Survey

Personnel trained in industrial hygiene surveyed the 881 Hillside Area on March 21, 1987 for the presence of volatile organics in ambient air. This survey was done with draeger tubes sensitive to PCE and TCE in the ppm range. These two compounds were chosen since investigations prior to March 1987 had indicated PCE and TCE were the most commonly found contaminants at the 881 Hillside Area, and they were also found in higher concentrations than other contaminants.

Air sampling was conducted six inches above the ground, at numerous point locations throughout the 881 Hillside Area. Results of this survey are presented in Table 6-1. As can be seen, all values were below detection limits except for two tetrachloroethene readings. These readings were located near a currently operating hazardous waste satellite collection area for solvents. It is conjectured that the hazardous waste satellite collection station was the source of the 2 and 3 ppm values of PCE rather than sources of volatile organics in the soil. Additionally, soil gas sampling results (Appendix B) of the 881 Hillside indicate only limited areas of detectable volatile organics present in the soil gas. It is believed that migration of contaminated soil gas

TABLE 6-1

AMBIENT AIR SAMPLING FOR
VOLATILE ORGANIC COMPOUNDS
AT THE 881 HILLSIDE AREA

LOCATION	SAMPLE NUMBER	PCE (ppm)	TCE (ppm)	COMMENTS
Hillside	B881-032187-01	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-02	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-03	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-04	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-05	3	0	3/21/87 *DREAGER TUBE*
	B881-032187-07	2	0	3/21/87 *DREAGER TUBE*
	B881-032187-08	0	0	3/21/87 *DREAGER TUBE*
	B881-032187-09	0	0	3/21/87 *DREAGER TUBE*
	N13488E21280	0	0	3/21/87 *DREAGER TUBE*
	N35000E21220	0	0	3/21/87 *DREAGER TUBE*
	N35000E21280	0	0	3/21/87 *DREAGER TUBE*
	N35060E21220	0	0	3/21/87 *DREAGER TUBE*
	N35060E21340	0	0	3/21/87 *DREAGER TUBE*
	N35060E21460	0	0	3/21/87 *DREAGER TUBE*
	N35120E21200	0	0	3/21/87 *DREAGER TUBE*
	N35120E21340	0	0	3/21/87 *DREAGER TUBE*
	N35120E21520	0	0	3/21/87 *DREAGER TUBE*
	N35120E21820	0	0	3/21/87 *DREAGER TUBE*
	N35180E21400	0	0	3/21/87 *DREAGER TUBE*
	N35180E21640	0	0	3/21/87 *DREAGER TUBE*
	N35180E21760	0	0	3/21/87 *DREAGER TUBE*
	N35240E21160	0	0	3/21/87 *DREAGER TUBE*
	N35240E21220	0	0	3/21/87 *DREAGER TUBE*
	N35300E21280	0	0	3/21/87 *DREAGER TUBE*
	N35300E21400	0	0	3/21/87 *DREAGER TUBE*
	N35300E22360	0	0	3/21/87 *DREAGER TUBE*
	N35420E21340	0	0	3/21/87 *DREAGER TUBE*
	N35420E21580	0	0	3/21/87 *DREAGER TUBE*
	N35420E21700	0	0	3/21/87 *DREAGER TUBE*
	N35420E21820	0	0	3/21/87 *DREAGER TUBE*
	N35420E22000	0	0	3/21/87 *DREAGER TUBE*
	N35900E23260	0	0	3/21/87 *DREAGER TUBE*

off the 881 Hillside Area is not occurring based upon 1986 soil gas data taken along Woman Creek (Rockwell International, 1986a). A more complete discussion of 1987 soil gas results is given in Sections 3 and 4. All of the above results demonstrate that only a minimal amount of volatile organics are contributed to ambient air by the 881 Hillside Area.

7.0 BIOTA

7.1 FLORA

The Rocky Flats Plant is located at an approximate elevation of 6,000 feet above mean sea level, at the elevation where plains grassland vegetation meets lower montane forest.

Within the Plant boundaries (which includes the 881 Hillside), a variety of vegetation thrives. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions. Introduced Eurasian weeds make up a significant portion of the vegetative cover. It is evident that the vegetative cover in the Rocky Flats region has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years. Land within the original 2,520-acre site boundary, however, has not been grazed since 1951 and generally has been undisturbed since that time. Some disturbed areas have been reseeded with native grass mixtures (DOE, 1980).

Weber and others (1974) conducted an inventory of the botany at the Rocky Flats site from June through September of 1973. They reported that 327 species of vascular plants, 25 lichens, 15 bryophytes, and one macroscopic green algae species had been observed in the area. An annotated list of species occurring on the Rocky Flats site is given in Appendix G, none being on the endangered species list (DOE, 1980).

Within the property boundary, but west of the security area, the substrate is composed largely of rock and coarse gravel; the vegetation is dominated by June grass, Klamath weed, and nodding thistle. This area is pock-marked by low gravel mounds, apparently formed by the activities of pocket gophers (Murray, 1967). These mounds

frequently support vegetation that is somewhat different from surrounding areas (DOE, 1980).

It appears that vegetation is recovering from grazing that occurred prior to Government acquisition of the land. This is evidenced by the presence of grasses like big bluestem and side-oats grama that are sensitive to disturbances. In 1975, about 4,000 acres surrounding the Plant site were purchased to enlarge the Plant's buffer zone. Much of the area lying between the old and new boundaries had been overgrazed; consequently, it supports a relatively sparse vegetative cover characterized by June grass, cheat grass, and Klamath weed (DOE, 1980).

Plant vegetation has been routinely sampled for levels of plutonium-238, -239, -240, and americium-241. From 1975 to 1983, this sampling was carried out by clipping vegetation within 1.0 m^2 frames located randomly at ten sites in each of two plots (Rockwell, 1983). Plot A was located southeast and relatively near the 903 Pad Area. Plot B was located northeast of the 903 Pad Area, approximately twice as far from the 903 Pad as Plot A. Control plots were located in various areas expected to be unaffected by Plant operations. The vegetation samples were dried, ashed, and analyzed for radionuclides (Rockwell, 1983). Prior to 1975, vegetation was sampled, ashed, and analyzed for radionuclides, but the vegetation sampling procedure was significantly different. The results of vegetation sampling and radionuclide analyses have remained comparable throughout all sampling events since 1975. Vegetation samples for the above radionuclides were last collected in 1983.

Significant variability has been seen in all plutonium data for vegetation. In general, levels of plutonium-239 and -240 in vegetation collected at Plot A have been elevated compared to vegetation collected at Plot B or in the control areas. The pluto-

nium-239 and -240 concentrations at Plot A have varied from 0.068 to 0.415 picocuries per gram of ash, whereas the concentrations of these radionuclides in Plot B have varied from 0.004 to 0.066 picocuries per gram of ash. The concentrations of these radionuclides in Plot B have been indistinguishable from the control plots (Rockwell, 1982; Rockwell, 1983). Concentrations of plutonium-238 and concentrations of americium-241 have shown no identifiable differences between plots. The data for individual plots have shown no discernible trends with time. No vegetation sampling for radionuclides has been conducted at the 881 Hillside Area. Vegetation sampling for radionuclides has only been conducted at the 903 Pad Area because that is where the highest concentrations are expected. Based on results of the radiometric survey (Section 6.2.1), radionuclides in surface soils or vegetation are anticipated not to be a problem at the 881 Hillside Area.

Vegetation at the 881 Hillside has not been sampled for levels of hazardous organics or metals since no vegetative stress has been noted. Further, no shallow surface soils contaminated with hazardous constituents have been found to date. Vegetation sampling will be conducted if vegetative stress of significant shallow surface soil contamination is found.

The flora of the 881 Hillside is as described previously. Vegetation is currently growing heavily throughout the area, with no vegetative stress noted. Soil in the area is relatively stable, with some limited areas of erosion and slumping on the western portion of the site. Efforts have been taken to minimize the field work's impact on vegetation in order to prevent erosion and areas of bare soil. Since Plant vegetation is not used for grazing of animals and is not harvested for use on- or off-site, no migration of hazardous constituents through vegetative uptake can occur. The above factors lead to the conclusion that there are no current vegetative problems.

7.2 WILDLIFE

A list of mammals, birds, amphibians, and reptiles observed at the Plant is given in Appendix G.

There are no effective barriers to animal migration or movement on or off the undeveloped areas of the Plant. This area supports a variety of animals classically associated with the western prairie regions. No rare or endangered species have been reported or have been found among the wildlife inhabiting or migrating through the area (Appendix G). The most common large mammal at the Rocky Flats site is the mule deer. Most of the estimated 100-125 deer appear to be permanent residents of the site. White-tailed jack rabbits and the desert cottontail also inhabit the area. Carnivores in the area include coyote, red fox, striped skunk, and long-tailed weasel. Badger and raccoon are occasionally observed. Muskrat occur in the vicinity of the streams and ponds (DOE, 1980).

Winsor and others (1975), initiated a mark-and-recapture program during the summer of 1973 to estimate dynamics and biomass of the small-mammal population. Species captured included deer mouse, thirteen-line ground squirrel, northern pocket gopher, hispid pocket mouse, silky pocket mouse, harvest mouse, meadow vole, and house mouse (DOE, 1980).

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrow. A variety of ducks, killdeer, and red-winged black birds are seen in areas adjacent to ponds. Mallards and other ducks frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks, red-tailed hawks, Ferruginius and American rough-legged hawks, and great horned owls (DOE, 1980).

Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow-bellied racers have also been seen. The eastern short-horned lizard has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle and the western plains garter snake are found in and around many of the ponds (DOE, 1980). Wildlife impacts near the 881 Hillside have not been noted to date, and little exposure to hazardous constituents should occur since no highly contaminated shallow surface soil has been found.

The potential for plutonium uptake into animals was investigated at the Plant to determine if there was a detrimental impact on the animals, as well as to determine what mass of plutonium was redistributed by animal uptake. Detailed studies were conducted on a number of small mammals, and a limited study was conducted on arthropods. The detailed studies included species occurrence, population density, biomass, reproduction, and physical size of the whole carcass as well as organs. Additionally, pathological examinations of small mammals were carried out by x-ray analysis of the skeleton, microscopy for lung tumors, and necropsy for general pathology and parasite occurrence. Arthropods were studied through community structure and biomass. These studies were conducted in areas contaminated with plutonium originating from the 903 Pad (Whicker, 1979).

Minor differences in biological attributes of animals and arthropods of contaminated and non-contaminated areas did occur, but none could be related to plutonium level. The levels of plutonium found in the tissues of animals living in contaminated areas were insufficient to produce radiation doses causing obvious biological changes, and no evidence of cancers or other radiogenic diseases was found. It is possible that subcellular biological effects such as chromosome aberrations may occur in areas highly contaminated with plutonium; however, population-level changes would likely not occur

due to interbreeding with the surrounding pool of normal genetic information. These studies indicate that plutonium, at the levels present at the site, is not expected to pose an ecological hazard.

No wildlife sampling for plutonium has been done at the 881 Hillside since plutonium has not been found there to date, and is not expected to be present in high concentrations at any of the sites in the area.

Ingestion of contaminated vegetation is expected to be the major route of biological uptake of hazardous constituents from the 881 Hillside. No food crops are grown at the 881 Hillside, and grazing of livestock is not permitted. No stressed vegetation has been noted, and large areas of shallow surface soil contaminated with hazardous constituents have not been found at the 881 Hillside. For these reasons, wildlife sampling for non-radioactive hazardous constituents has not been conducted at the 881 Hillside.

7.3 AQUATIC LIFE

Woman Creek is an ephemeral stream that runs through the area south of the 881 Hillside. This stream receives snowmelt, storm runoff, and irrigation water, it does not currently receive discharges from Plant operations. The stream previously received cooling tower blowdown, which was discontinued in late 1974, and water treatment plant filter backwash, which was discontinued in 1975 as discharges from the Plant. Holding pond C-1 collects stream water and is used as a monitoring point for Woman Creek. Holding pond C-2 collects stormwater runoff from the South Interceptor Ditch. This diversion system, including pond C-2, is isolated from Woman Creek, and is sampled before discharge. Woman Creek supports an aquatic biota typical of small high-prairie streams receiving a minimum of agricultural land runoff and domestic or industrial wastes. Due to the low nutrient content in Woman Creek, the stream supports only a

small algal population. The rocky bottom of Woman Creek supports a relatively diverse biota composed of mayflies, caddisflies, and other forms typical of clean water streams. Redside dace minnows are abundant in the stream and in the ponds; a few bluegill are also present. A list of the aquatic organisms known to occur in the streams and ponds of the Plant area is given in Appendix G.

Woman Creek water and sediments have been sampled for both radionuclides and hazardous constituents. The results of these sampling activities are discussed in Section 5.0 of this report. Except at station SW-32, elevated levels of hazardous contaminants have not been found in Woman Creek water. The significance of this isolated incidence of contamination is unclear therefore, a biological sampling of the stream system is not justified at this time. Impacts of potential remedial alternatives on the stream will be evaluated, and additional sampling will be conducted if necessary.

8.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

This section identifies potential receptors, public health impacts, and the environmental impacts of contaminants found at the 881 Hillside Area. Previous sections of this report have described remedial investigation sampling results. Samples were collected from air, soils, sediment, surface water, ground water, flora, and fauna. Soil gas techniques and geophysical techniques were also used to investigate areas of the 881 Hillside. These data were used to evaluate contaminant presence, distribution, migration, and fate.

As discussed in Sections 3 and 4, contaminated soil and ground water occur at the 881 Hillside. The principal contaminants found in soils are the semi-volatile organic compound bis(2-ethylhexyl)phthalate in concentrations up to 3800 ppb, and the volatile organic compound 2-butanone in concentrations up to 370 ppb. Lower concentrations, less than 100 ppb, of some other volatile organics were also detected in soil samples from some areas. Radiochemical data was unavailable at the time of this writing. The principal contaminants found in the ground water are the volatile organics and radionuclides. Maximum concentrations of volatiles were trichloroethene (20,000 ppb), tetrachloroethene (or perchloroethene 6400 ppb), 1,2-dichloroethane (4500 ppb), 1,1,1-trichloroethane (14000 ppb), and 1,1-dichloroethene (12,400 ppb). Maximum concentrations of radionuclides were Pu (1.3 pCi/l), Am (6.6 pCi/l), U^{234} (15 pCi/l), and U^{238} (33 pCi/l).

At this time, quality assurance/quality control data compilation and review is incomplete. Therefore, the data reported and corresponding discussions pertaining to exposure assessments in this section of the draft report are subject to re-interpretation.

8.1 POTENTIAL RECEPTORS

Based on 1980 Census data, approximately 1,585 individuals live within four miles of the Rocky Flats Plant. Approximately 2 million people live within a 50 mile radius of the Plant. Population density is greatest to the south and east of the Plant (Figure 2-1). A buffer zone around the manufacturing facilities is maintained as a restricted access area by the Plant and is actively patrolled by armed security guards. Therefore, a residence closer than 1.6 miles from the 881 Hillside Area is not possible. Currently the closest residence is 2.1 miles from the center of the 881 Hillside. The only possible routes of exposure to 881 Hillside contamination are through: direct exposure to waste sources and contaminated soil, inhalation of contaminated air, ingestion of contaminated ground water, and ingestion of contaminated surface water. Without primary exposure to contaminants through one of the above media, no secondary exposure to contamination can occur. Secondary exposure to contamination is defined as exposure to contamination caused by a change in the mode of transport of that contaminant. For instance, primary migration of volatile organics may occur in the surface water of a creek. Secondary exposure could occur through consumption of food crops that have taken up the volatile organic compounds from irrigation water whose source was that contaminated creek.

8.1.1 Direct Source Contact Potential Receptors

Since the entire 881 Hillside Area is within the Plant security area or buffer zone, direct exposure of the public to contaminated soil is not possible since access to both the Plant and the buffer zone is restricted. Any potential for contact with contaminated soil will be limited to workers involved in investigative and remedial activities. All remedial action workers will be protected by protective clothing, the use of respirators when necessary, and by air monitoring during field activities. Industrial

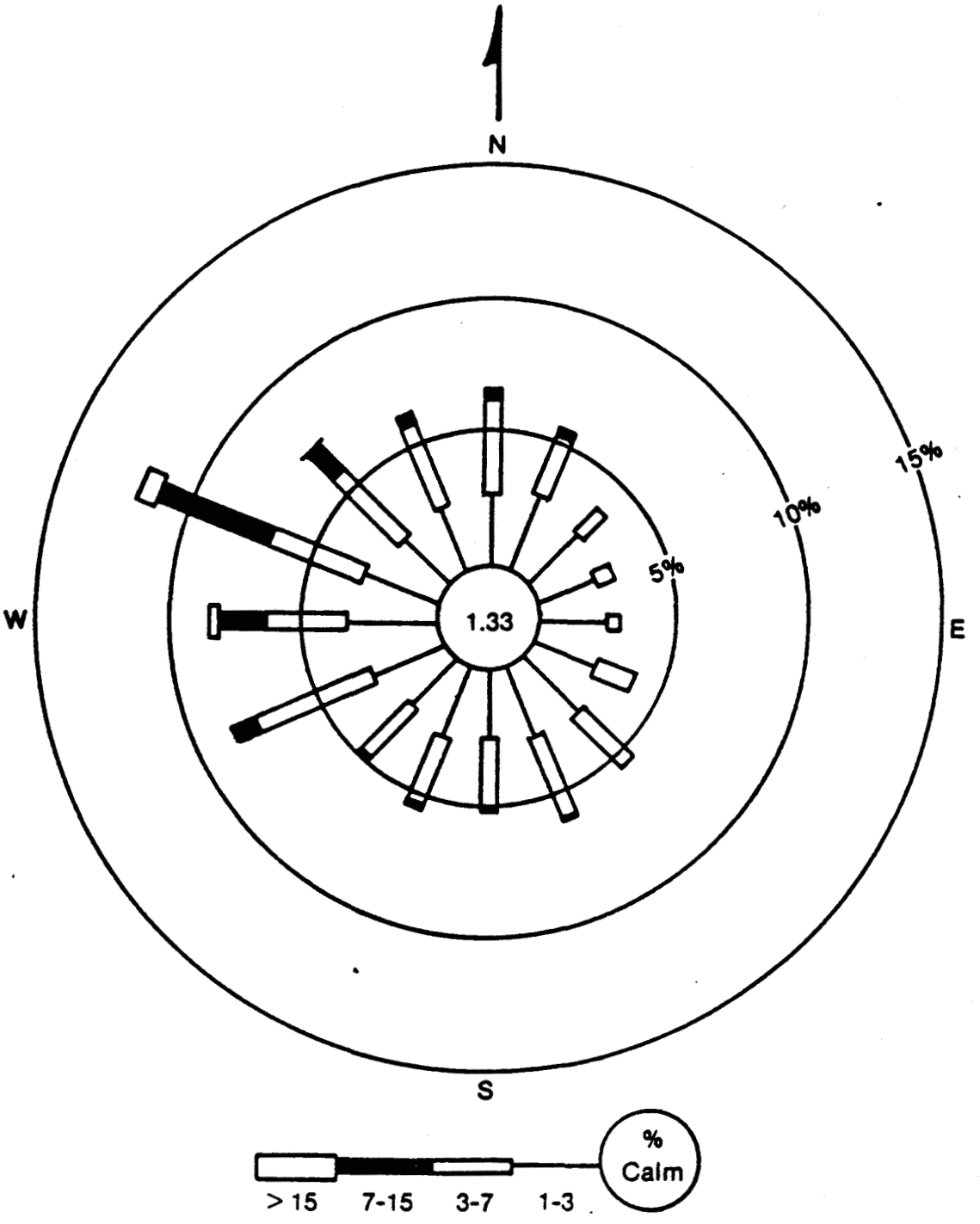
hygienists and health physicists will prepare a personnel protection plan prior to the initiation of remedial activities.

8.1.2 Potential Receptors of Contaminated Air

Long-term exposure of individuals to directly resuspended dust and to contaminated air can occur to those individuals that are residents near the Plant because greater distances from the Plant will cause dilution of any plume by advection, dispersion, and diffusion. These individuals would further need to be within a plume of contamination leaving the Plant. Winds at the Plant are predominantly from the northwest. A wind rose for the Plant is provided in Figure 8-1. The low population density within four miles of the plant indicates that relatively few individuals are potential receptors of contaminated soil or gas.

8.1.3 Potential Receptors of Contaminated Groundwater

Table 8-1 presents all water supply well locations within two miles of the 881 Hillside Area. The closest downgradient water supply wells (wells 11, 12, 13, 16, 17, 20) are outside the two mile radius but have been included in Table 8-1. Their locations were obtained from records in the Colorado State Engineer's Office. The locations for wells 11 and 12, approximately 2.2 miles east and north of the 881 Hillside Area could not be physically located in the summer of 1986. These two wells would be located on City of Broomfield land, and City employees had no knowledge of these wells (Rockwell International, 1986c). The majority of the wells presented in Table 8-1 are used as drinking water for either humans or livestock. The nearest registered downgradient wells (wells 20, 13, 16, and 17) are located approximately 2.6 miles east and slightly south of the 881 Hillside Area.



WESTON MANAGERS DESIGNERS/CONSULTANTS
215 Union Boulevard
Suite 600
Lakewood, CO 80228
(303) 980-6800

ROCKWELL INTERNATIONAL
Rocky Flats Plant

FIGURE 8-1

1985 ANNUAL WIND ROSE FOR THE ROCKY FLATS PLANT

TABLE 8-1
WELLS WITHIN TWO MILES OF
THE 881 HILLSIDE AREA,
PLUS THE NEAREST DOWNGRADIENT WELLS

PERMIT NUMBER	LOCATION				USE	WELL DEPTH (feet)	WATER LEVEL (feet)	YIELD (gpm)	OWNER	DATE WELL CONSTRUCTED
	QUARTER	SEC.	TSP.	RNG.						
119287	SW/NW	31	T.1S	R.69W	1	Unk	Unk	Unk	Roberts, B.A.	4/22/81
105613A	NE/NW	31	T.1S	R.69W	1	Unk	Unk	Unk	Hart, G.D.	6/22/79
108871	NW/NW	31	T.1S	R.69W	1	Unk	Unk	Unk	Smith, M.R.	7/23/79
105681	NE/NE	32	T.1S	R.69W	0	Unk	Unk	Unk	Fuentes, J.J.	4/18/79
106022A	NW/NW	32	T.1S	R.69W	1	Unk	Unk	Unk	Kingsburg, D.	5/4/79
121149	NW/NW	32	T.1S	R.69W	1	Unk	Unk	Unk	Kois, R.W.	7/28/81
104756	NE/NE	19	T.2S	R.69W	0	Unk	Unk	Unk	Welt, D.L.	4/8/81
26942F	NE/NW	19	T.2S	R.69W	8	Unk	Unk	Unk	Cook, M.E.	11/8/84
139972	SE/SE	19	T.2S	R.69W	3	Unk	Unk	Unk	Coleman, J.R.	6/17/85
131841	NE/NW	19	T.2S	R.69W	6	Unk	Unk	Unk	Cook, M.E.	8/2/83
26937F	NW/NW	19	T.2S	R.69W	8	Unk	Unk	Unk	Cook, M.E.	11/3/84
26	NE/NE	19	T.2S	R.69W	1	66	27	15	Ladwig, A.E.	6/27/57
223	SW/SE	19	T.2S	R.69W	1	110	10	6	Schofield, James & Betty	8/28/57

8.1.4 Potential Receptors of Contaminated Surface Water

The ephemeral stream Woman Creek flows to the south of the 881 Hillside, and this creek enters Standley Lake approximately four miles east of the Plant boundary. Standley Lake supplies drinking water to approximately 150,000 inhabitants of the cities of Westminster, Northglenn, and Thornton. Standley Lake is also used for irrigation water, boating, and fishing.

8.2 PUBLIC HEALTH IMPACTS

8.2.1 Direct Source Contact Exposure

As discussed in Section 8.1.1, there is no potential for direct exposure of the public , or any livestock, to the 881 Hillside Area contamination. There is no public health impact for this route of exposure.

8.2.2 Exposure to Contaminated Air

An extensive air monitoring network known as the Radioactive Ambient Air Monitoring Program (RAAMP) is maintained at the Plant. This network has found ambient air samples to be well within applicable regulations and guidelines for the protection of human health and the environment for all radioactive contaminants monitored that could possibly have originated from the 881 Hillside Area. No anomalous values were noted that correlated with any of the 881 Hillside field activities.

As discussed in Section 6, movement of resuspended dust at the Plant does not follow classical saltation theory, with lower than predicted concentrations of dust resuspended in the air. The majority of this resuspended dust settles out within one kilometer of the Plant. Also, the RAAMP system has detected only very low levels of ambient radioactivity on captured resuspended dust particles. These facts demonstrate that windblown distribution of contaminated soil from the 881 Hillside is not a concern.

Further, ambient air sampling for volatile organic compounds was performed 6 inches above the land surface at the 881 Hillside. Only at two areas were organic compounds detected. Organic concentrations were very close to the detection capability of the instrument, and were ascribed to a temporary holding area for drums of hazardous waste (SWMU 177).

Ambient air sampling in the breathing zone for volatile organics during drilling activities at the 881 Hillside failed to detect the presence of volatile organics. Based on the lack of detectable contamination of air due to any of the 881 Hillside activities, there is no public health impact from the air pathway.

8.2.3 Exposure to Contaminated Ground water

An extensive ground water monitoring system has been installed at the Plant. Nineteen ground water monitoring wells are associated with the 881 Hillside Area. Wells 9-74, 10-74, 1-82, 61-86, and 4-87 are contaminated with volatile organic compounds. Although general ground water flow at the Plant is toward the east, the direction of flow in surficial materials in the immediate 881 Hillside Area is to the south, toward the South Interceptor Ditch and Woman Creek. It is currently believed that contaminated ground water discharges either to the South Interceptor Ditch or to Woman Creek as surface water, or continues movement as ground water within the valley fill alluvium of the Woman Creek drainage. These surface waters are "clean" downgradient of the 881 Hillside Area. Recent data from ground water monitoring well 64-86 shows elevated Pu (0.63 pCi/l) and Am (0.55 pCi/l); however, historical data for well 15-74 and current data for well 65-86 located downgradient of 64-86 have shown background levels of plutonium and americium.

8.2.4 Exposure to Contaminated Surface Water

Sampling and analysis for volatile organics has not been routinely conducted for surface water near the 881 Hillside, but volatile organic compound samples were taken in 1986 and 1987 and will continue to be taken in the future. Nine surface water and surface seep samples in the vicinity of the 881 Hillside were sampled during the 1987 field activities. Only two of these samples were found to contain volatile organics. Sample SW-45 was a sample of a footing drain that supplies water to a skimming pond on the 881 Hillside. This sample had 128 ppb of PCE and 14 ppb of TCE. The discharge from the skimming pond is piped directly to the South Interceptor Ditch. A sample of the discharge from skimming pond where it enters the South Interceptor Ditch (SW-44) had 4 ppb of PCE only. It appears that these volatile organics volatilized to the air during detention in the pond and flow from SW-45 to SW-44. These sampling points are separated by approximately 150 lineal feet, but the approximate flow time is 18 hours at the measured flow rate of 5 gallons per minute. This reduction in volatile organic concentration is not surprising given the volatility of these compounds and the turbulent nature of surface water flow. The fate of volatile organics present in ground water discharging to either the South Interceptor Ditch or Woman Creek is also volatilization to the ambient air. Supporting this conclusion is the fact that no volatile organic compounds were detected in surface water samples from both the South Interceptor Ditch (Sample SW-30) and Pond C-1 (Sample SW-29). Both sampling stations are located downstream of the 881 Hillside.

With regard to radionuclides, it appears the Interceptor Ditch is largely impacted by the old landfill or another unknown and nearby release site, with some additional impacts by the 881 Hillside. Contaminants released of greatest concern are plutonium and americium. However, water quality in Pond C-2 does not appear to be adversely

impacted by these releases, indicating dilution, precipitation, and/or adsorption as attenuating mechanisms.

At station SW-32 on Woman Creek just downstream of the confluence with it's southern tributary, August 1986 data indicate plutonium was 0.23 pCi/l and other radionuclides were typical of stream concentrations. The May 1987 data also show elevated plutonium (0.66 pCi/l) as well as elevated americium (0.60 pCi/l), and uranium$^{233 + 234}$ (3.4 pCi/l). However, like the Interceptor Ditch, data from stations SW-C1 (Pond C-1), SW-29, and SW-28, all located downstream of the 881 Hillside, do not show any indications of a radionuclide release from the 881 Hillside impacting Woman Creek.

It is concluded that any contamination present in surface water near the 881 Hillside Area is removed by natural processes before the water migrates far from the 881 Hillside. No contaminated surface water is leaving the Plant site. Therefore, there is no off-site contaminant transport, and consequently no public health impact from contaminated surface water.

8.3 ENVIRONMENTAL IMPACTS

Environmental impacts of the 881 Hillside Area appear to be entirely confined to the 881 Hillside Area, as previously concluded in this report. Detectable air contamination has not and is not occurring, even directly over the 881 Hillside Area (Section 6). Ground water contaminated with volatile organic compounds and radionuclides is found at the 881 Hillside Area, but migration is slow due to the limited quantities of ground water, the relatively impermeable soils of the site, and frequent surfacing of ground water flow. Elevated radionuclide concentrations were reported for one well in the valley fill alluvium of Woman Creek; however, current and historical

data for wells downgradient of this point do not show radionuclide contamination. Low concentrations of volatile organic contaminants are found in some surface waters of the 881 Hillside, but volatilization of these contaminants is occurring prior to migration off the 881 Hillside Area (Section 5). Therefore, environmental impacts of the 881 Hillside Area appear to be entirely confined to the 881 Hillside Area. These environmental impacts are: the presence of soil contaminated with semi-volatile organic compounds, the presence of ground water contaminated with volatile organic compounds and radionuclides, and the presence of surface water contaminated with low concentrations of volatile organic compounds and radionuclides.

Contaminated soil at the 881 Hillside was typically found at some depth from the soil surface. No chemicals have been disposed in the soil since 1972. Therefore, volatilization and biodegradation of organic compounds in the upper soil layers has occurred for 15 years. This time period represents 391 half-lives (no distinction made between fraction volatilized and fraction biodegraded) for the soil degradation of bis(2-ethylhexyl)phthalate - the most common and the most highly concentrated contaminant found in the soil at the site (API, 1984). Stressed or burned vegetation was not observed at the Hillside during field activities.

Ground water contaminated with volatile organics and radionuclides was found in isolated areas of the 881 Hillside. Although some relatively high volatile organic concentrations occur, usable quantities of ground water were not found and ground-water flow rates were low. The use of this ground water for domestic, commercial, or industrial purposes near the 881 Hillside has never been intended and is not planned in the future. These facts mitigate the potential environmental impacts of the contaminated ground water.

Some surface water contaminated with volatile organics and radionuclides is found at the 881 Hillside. The greatest total concentration of volatile organics compounds was 142 ppb. Approximately 150 feet downstream (approximate flow time of 18 hours) 4 ppb of volatile organics were detected. Signs of environmental (biological) stress were not apparent at the 881 Hillside during the investigation. Sow bugs, caddis flies, and numerous phreatophytes were observed in and near the flowing portion of the contaminated surface water. Sow bugs, caddis flies, amphibians, algae, and phreatophytes were also observed in and near the quiescent areas of the contaminated surface water.

In summary, the environmental media in limited areas of the 881 Hillside is contaminated with varying levels of hazardous substances and low levels of Pu and Am. This area is not used, nor intended for use as a public or recreational area, or for the development of any unique natural resource. No levels of contamination were found that would preclude the use of this land for the construction of buildings. No unique ecosystems or endangered species have been observed at the Plant during extensive biological studies. The biota present at the 881 Hillside does not exhibit obvious stress. For all of these reasons, there are no public health impacts expected due to contamination at the 881 Hillside Area, and the 881 Hillside Area poses only a minimal environmental threat.

9.0 REFERENCES

ACGIH, 1986, Documentation of the Threshold Limit Values and Biological Exposure Indices; American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

API, 1984; Land Treatability of Appendix VIII Constituents Present in Petroleum Industry Waste, American Petroleum Institute, Washington, D.C.; Publication 4379.

Case, D. R., Foweler, E. B., Henderson, R. W., and Milligan, M. F., 1971, "Experience Gained from an Extensive Operational Evaluation of the FIDLE", Proceedings of the Environmental Plutonium Symposium, August 4-5, 1971; Los Alamos Scientific Laboratory.

CMA, 1984, "Position Statement of the Phthalate Ester Panel on the Safety of Phthalate Esters"; Chemical Manufacturers Association, Washington, D.C.

Crow, L.W., 1974, Characteristic Airflow Patterns near Rocky Flats Plant and their Relationship to Metropolitan Denver, Final EIS, Rocky Flats Site, Appendix B.

Dames and Moore, 1981, Geologic and Seismologic Investigations for Rocky Flats Plant, Contract DE-AC04-80A110890.

DOE, 1980, Final Environmental Impact Statement: Rocky Flats Plant Site, Golden, Jefferson County, Colorado, Volumes 1, 2, and 3; U.S. Department of Energy Report; Washington, D.C., DOE/EIS-0064.

DOE, 1986a, Comprehensive Environmental Assessment and Response Program Phase 2: Generic Monitoring Plan, U.S. Department of Energy; Albuquerque Operations Office, unnumbered report.

DOE, 1986b, Comprehensive Environmental Assessment and Response Program Phase 1: Draft Installation Assessment Rocky Flast Plant; U.S. Department of Energy, unnumbered draft report.

DOE, 1987a, Comprehensive Environmental Assessment and Response Program Phase 2: Rocky Flats Plant, Draft Installation Generic Monitoring Plan; U.S. Department of Energy.

DOE, 1987b, Comprehensive Environmental Assessment and Response Program Phase 2: Rocky Flats Plant, Draft Site-Specific Monitoring Plan; U.S. Department of Energy.

DOE, 1987c, Letter to Ms. J. Sowinski, Colorado Department of Health, and Mr. R.L. Duprey, Environmental Protection Agency, dated February 16, 1987.

EPA, 1983, Hazardous Waste Land Treatment; Office of Research and Development, Municipal Environmental Research Laboratories, Cincinnati, Ohio, SW-874.

EPA, 1985, Guidance on Feasibility Studies Under CERCLA; U.S. Environmental Protection Agency report EPA-540/G-85/003, Cincinnati, Ohio, and Washington, D.C.

EPA, 1986, "Proposed Changes to Drinking Water Standards", Federal Register, Volume 51, Number 159, September 30, 1986.

Fenneman, N.M., 1931, Physiography of Western United States; McGraw Hill Book Company, New York, p. 534.

Hurr, R.T., 1976, Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado; U.S. Geological Survey Open-File Report 76-268.

Hydro-Search, Inc., 1985, Hydrogeologic Characterization of the Rocky Flats Plant, Golden, Colorado; Project No. 1520.

Hydro-Search, Inc., 1986, Electromagnetic Survey, Rocky Flats Plant, Golden, Colorado; Project No. 106G05502.

Leroy & Weimer, 1971.

Murray, D.F., 1967, "Gravel Mounds at Rocky Rlats, Colorado", The Mountain Geologist, Volume 4.

Rockwell International, 1975, Annual Environmental Monitoring Report: January-December 1974; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-74.

Rockwell International, 1976, Annual Environmental Monitoring Report: January-December 1975; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-75.

Rockwell International, 1977, Annual Environmental Monitoring Report: January-December 1976; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-76.

Rockwell International, 1978, Annual Environmental Monitoring Report: January-December 1977; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-77.

Rockwell International, 1979, Annual Environmental Monitoring Report: January-December 1978; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-78.

Rockwell International, 1980, Annual Environmental Monitoring Report: January-December 1979; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-79.

Rockwell International, 1981a, Annual Environmental Monitoring Report: January-December 1980; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-80.

Rockwell International, 1981b, Environmental Sciences Branch Semiannual Progress Report: January-June 1980; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-3197.

Rockwell International, 1981c, Environmental Sciences Branch Progress Report for 1979; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-3115.

Rockwell International, 1982a, Annual Environmental Monitoring Report: January-December 1981; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-RNV-81.

Rockwell International, 1982b, Environmental Sciences Branch, Semiannual Progress Report, January-June 1981; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-3325.

Rockwell International, 1983a, Annual Environmental Monitoring Report: January-December 1982; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-82.

Rockwell International, 1983b, Environmental Sciences Branch Progress Report: July-December 1981; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-3464.

Rockwell International, 1984a, Annual Environmental Monitoring Report: January-December 1983; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-83.

Rockwell International, 1984b, Environmental Sciences Group, Progress Report: January-July 1982; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-3650.

Rockwell International, 1985, Annual Environmental Monitoring Report: January-December 1984; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-84.

Rockwell International, 1986a, Resource Conservation and Recovery Act Part B - Operations Permit Application for USDOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes; U.S. Department of Energy, unnumbered report.

Rockwell International, 1986b, Draft Preliminary Prioritization of Sites; U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado.

Rockwell International, 1986c, Resource Conservation and Recovery Act Part B - Post-Closure Care Permit Application for U.S. DOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes; U.S. Department of Energy, unnumbered report.

Rockwell International, 1986d, Draft Work Plan, Geological and Hydrological Site Characterization; U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado.

Rockwell International, 1986e, Draft Project Operations Plan, Geological and Hydrological Site Characterization; U.S. Department of Energy, Rocky Flats Plant, Golden, Colorado.

Rockwell International, 1986f, Rocky Flats Plant Radioecology and Airborne Pathway Summary Report; Rockwell International, Rocky Flats Plant, Golden, Colorado, unnumbered report.

Rockwell International, 1986g, Annual Environmental Monitoring Report: January-December 1985; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-84.

Rockwell International, 1987, Annual Environmental Monitoring Report: January-December 1986; Rockwell International, Rocky Flats Plant, Golden, Colorado, report RFP-ENV-86.

Sax, R.J., and R.J. Lewis, Sr., 1987, Hawley's Condensed Chemical Dictionary, 11th edition; Van Norstrand Reinhold, New York, New York.

Scott, G.R., 1960, "Quaternary Sequence East of the Front Range Near Denver, Colorado", in Guide to Geology of Colorado, by Weimer, R.J., and Haun, J.D. (eds.); Geological Society of America, Rocky Mountain Association Geologists, Colorado Scientific Society, pp. 206-211.

Scott, G.R., 1963, Quaternary Geology and Geomorphic History of the Kassler Quadrangle, Colorado; U.S. Geologic Survey Prof. Paper 421-A.

Scott, G.R., 1965, "Nonglacial Quaternary Geology of the Southern and Middle Rocky Mountains", in The Quaternary of the United States; Princeton University Press, pp. 243-254.

Spencer, F.D., 1961, Bedrock Geology of the Louisville Quadrangle, Colorado, U.S. Geological Survey, Geol. Quad. Map GQ-151.

Tracer Research Corporation, 1986, Shallow Soil Gas Investigation of the Rocky Flats Plant, Golden, Colorado.

U.S. Department of Health and Human Services, 1985, "Fourth Annual Report on Carcinogens, Summary"; Document NTP 85-002, Washington, D.C.

Van Horn, R., 1972, Surficial and Bedrock Geologic Map of the Golden Quadrangle, Jefferson County, Colorado; U.S. Geologic Survey Misc. Geol. Field Inv. Map I-761-A.

Weber, W.A., Kunkel, G., and L. Schultz, 1974, A Botanical Inventory of the Rocky Flats Atomic Energy Commission Site, Final Report; University of Colorado, Boulder, Colorado, report COO-2371-2.

Whicker, F.W., 1979, Radioecology of Natural Systems, Final Report, Period of May 1, 1962-October 31, 1979; Colorado State University, Fort Collins, Colorado, report COO-1156-117.

Winson, T.F., 1975, "Plutonium in the Terrestrial Environs of Rocky Flats, Radioecology of Natural Systems in Colorado", Thirteenth Technical Progress Report; Colorado State University, Department of Radiology and Radiation Biology, Fort Collins, Colorado.

Revised SWMU 104
50' X 50'

SWMU's 105.1 & 105.2
As in Previous Documents

Revised SWMU 103 -
80' X 80' (103.2)

Revised
SWMU 130

SWMU 119.2
As in Previous
Documents

Revised
SWMU 119.1

SWMU 145
As in Previous
Documents

Revised SWMU 103 -
180' X 70' (103.1)

SWMU 102
As in Previous
Documents

SWMU 106
As in Previous
Documents

SWMU 107
As in Previous
Documents

N 749000
N 748500
N 748000
N 747500
N 36000
N 35500
N 35000
N 34500
E 20000
E 20500
E 21000
E 21500
E 22000
E 22500
E 23000

N

0 50 100 200
Scale 1" = 100
Contour interval = 2'

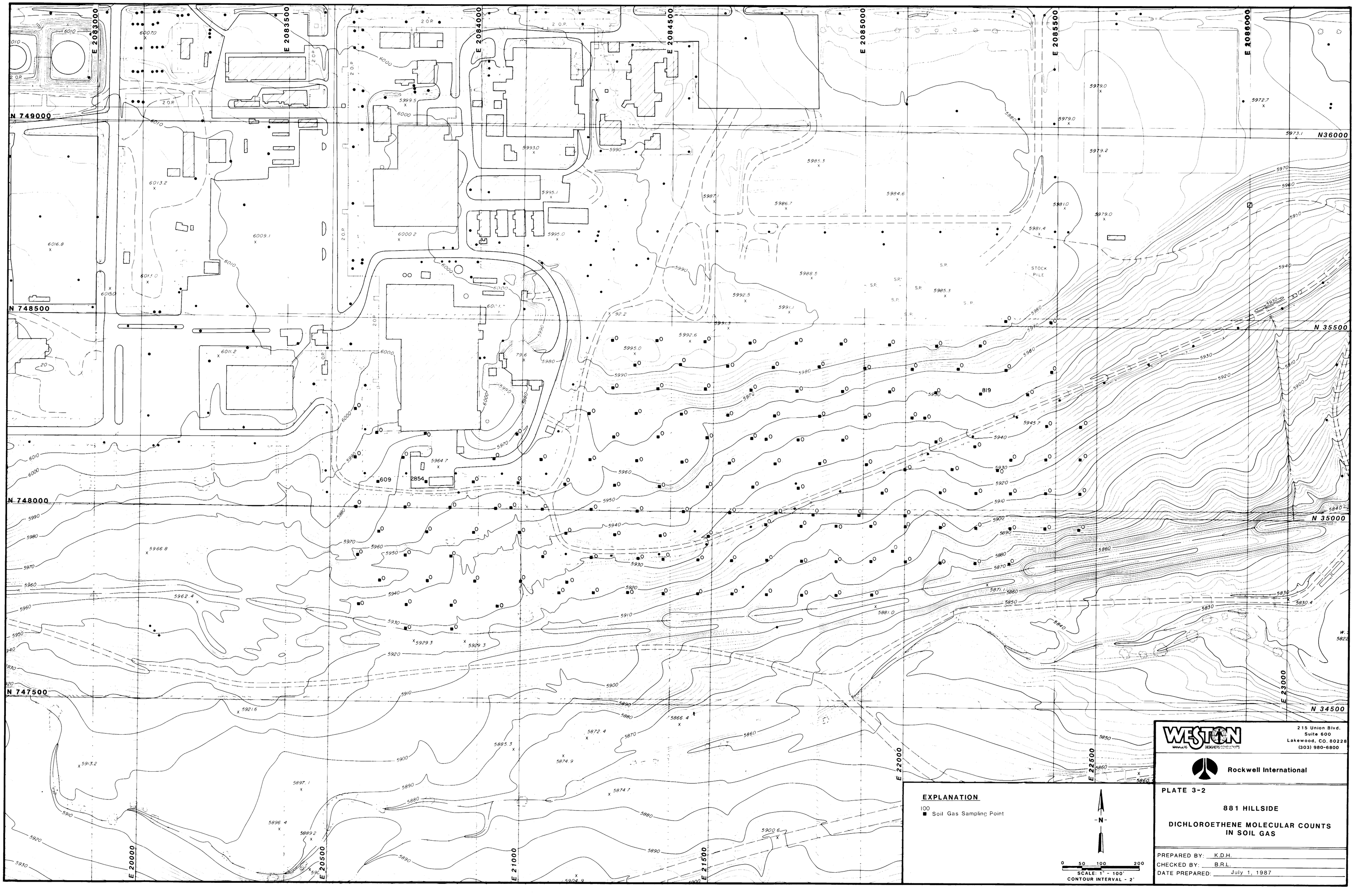
WESTON MANAGERS DESIGNERS CONSULTANTS
215 Union Blvd.
Suite 600
Lakewood, CO. 80228
(303) 980-6800

Rockwell International

PLATE 3-1

881 HILLSIDE
REVISED SOLID WASTE
MANAGEMENT UNIT LOCATIONS

PREPARED BY: F.J.B.
CHECKED BY: S.S.P.
DATE PREPARED: JULY 1, 1987



WESTON MANAGERS DESIGNERS CONSULTANTS
215 Union Blvd.
Suite 600
Lakewood, CO. 80228
(303) 980-6800

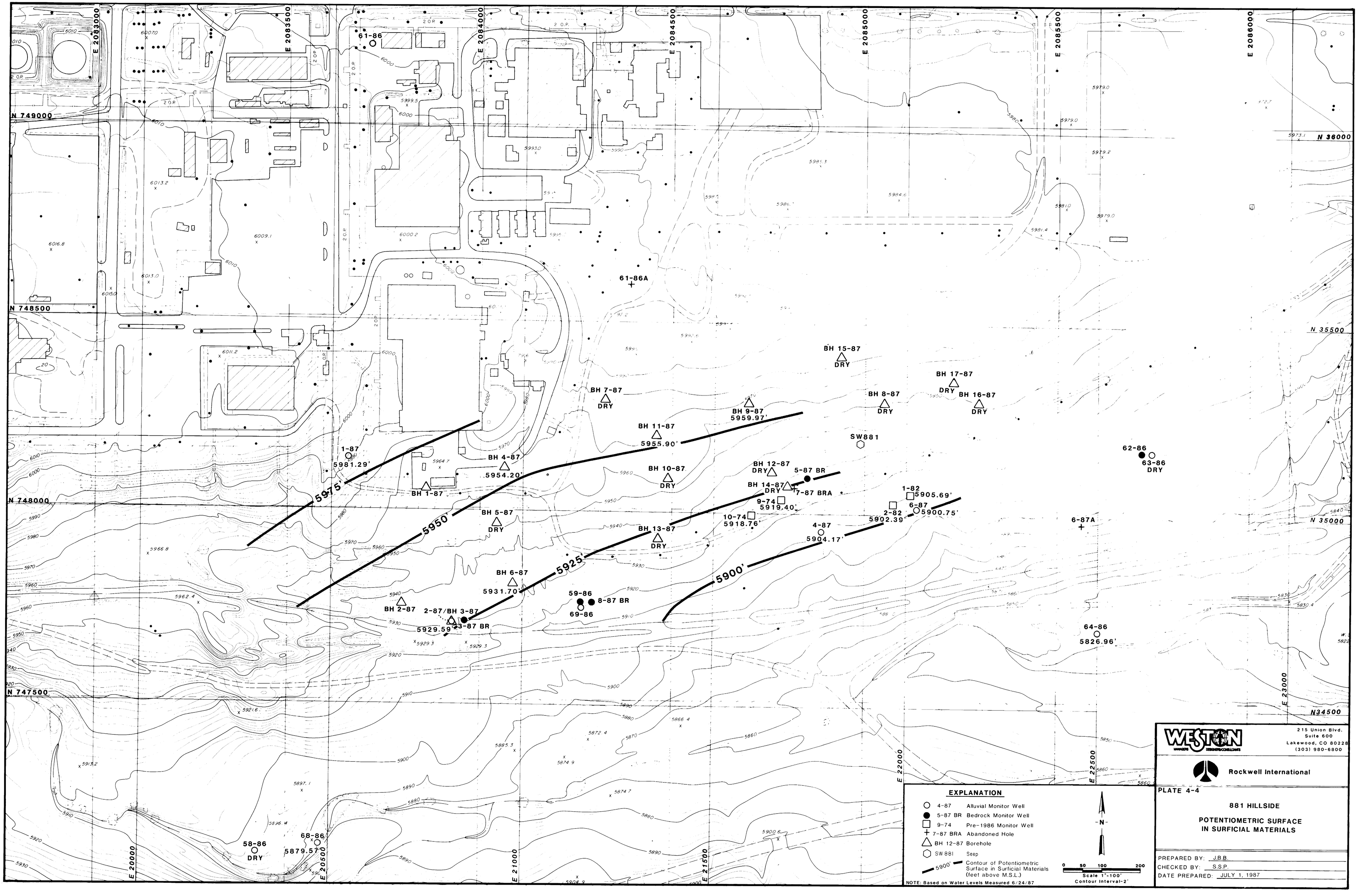
Rockwell International

PLATE 3-2

881 HILLSIDE

DICHLOROETHENE MOLECULAR COUNTS IN SOIL GAS

PREPARED BY: K.D.H.
CHECKED BY: B.R.L.
DATE PREPARED: July 1, 1987



EXPLANATION

- 4-87 Alluvial Monitor Well
- 5-87 BR Bedrock Monitor Well
- 9-74 Pre-1986 Monitor Well
- 7-87 BRA Abandoned Hole
- BH 12-87 Borehole
- SW881 Seep
- 5900' Contour of Potentiometric Surface in Surficial Materials (feet above M.S.L.)

NOTE: Based on Water Levels Measured 6/24/87

N

0 50 100 200
Scale 1"=100'
Contour Interval-2'

WESTON MANAGERS DESIGNERS CONSULTANTS
215 Union Blvd.
Suite 600
Lakewood, CO 80228
(303) 980-6800

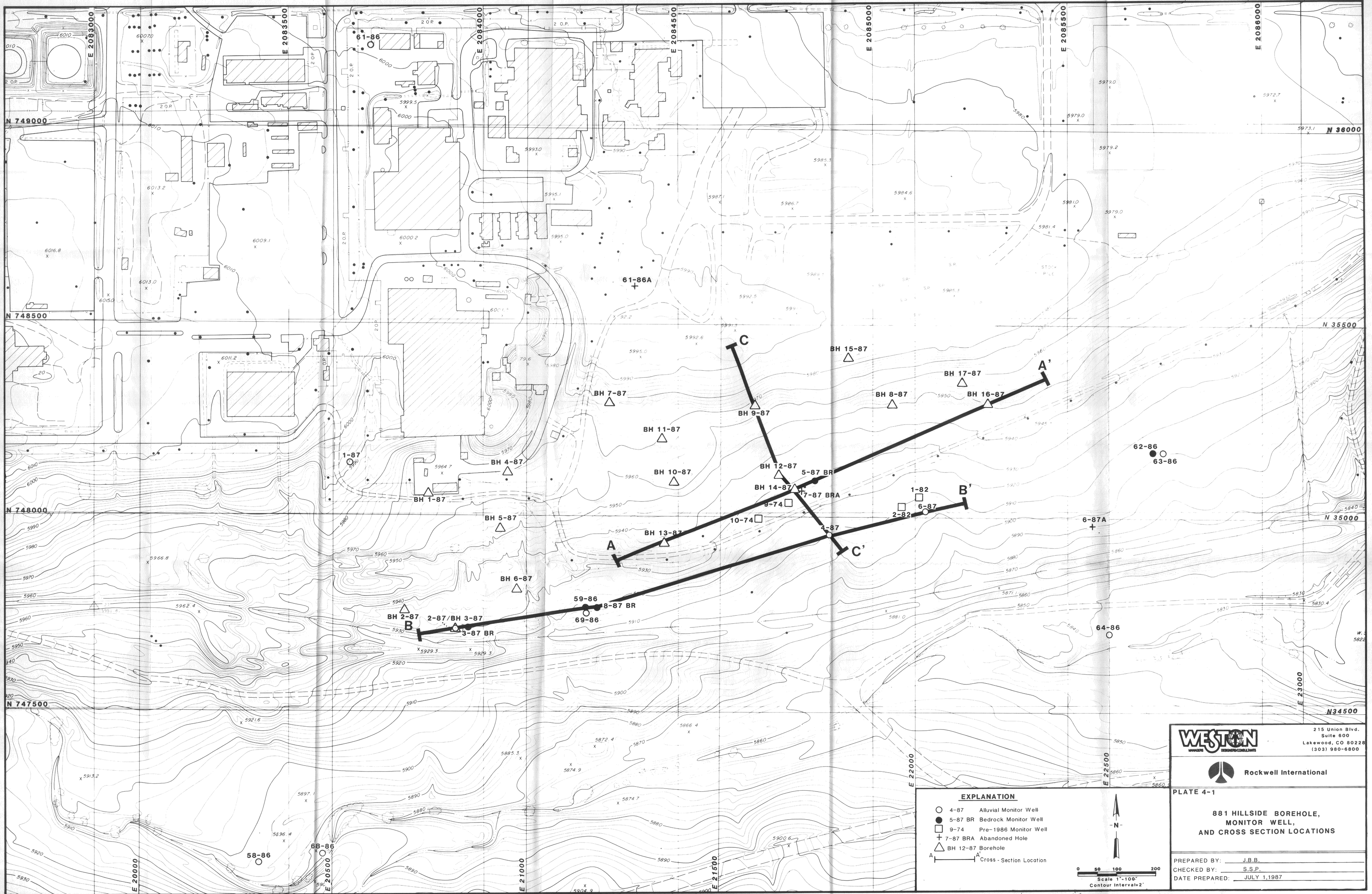
Rockwell International

PLATE 4-4

881 HILLSIDE

POTENTIOMETRIC SURFACE IN SURFICIAL MATERIALS

PREPARED BY: J.B.B.
CHECKED BY: S.S.P.
DATE PREPARED: JULY 1, 1987



EXPLANATION

- 4-87 Alluvial Monitor Well
- 5-87 BR Bedrock Monitor Well
- 9-74 Pre-1986 Monitor Well
- 7-87 BRA Abandoned Hole
- BH 12-87 Borehole
- A — A' Cross-Section Location

N

0 50 100 200

Scale 1"=100'
Contour Interval=2'

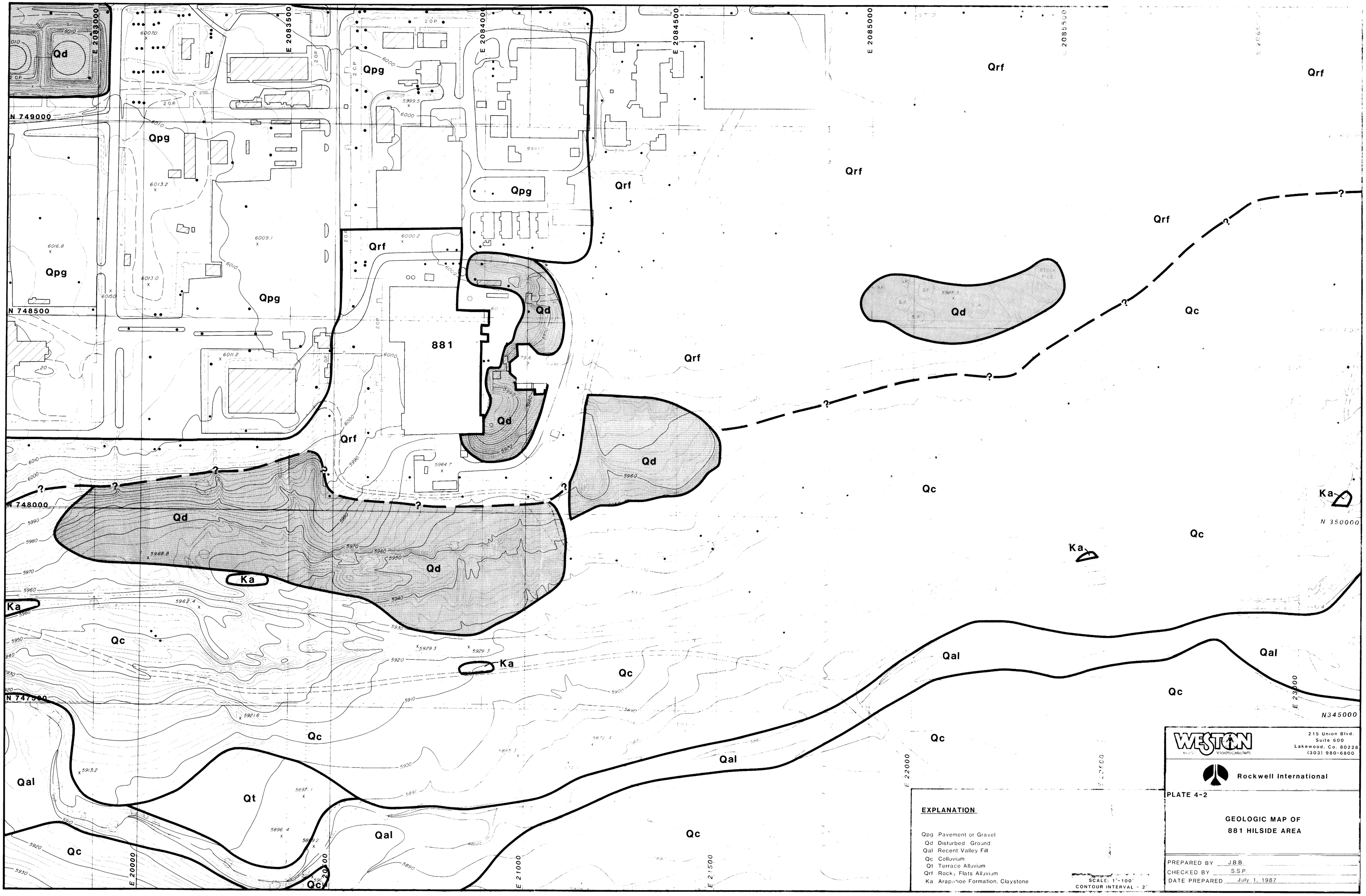
WESTON MANAGERS DESIGNERS/CONSULTANTS
215 Union Blvd.
Suite 600
Lakewood, CO 80228
(303) 980-6800

Rockwell International

PLATE 4-1

881 HILLSIDE BOREHOLE, MONITOR WELL, AND CROSS SECTION LOCATIONS

PREPARED BY: J.B.B.
CHECKED BY: S.S.P.
DATE PREPARED: JULY 1,1987



EXPLANATION

Qpg Pavement or Gravel
Qd Disturbed Ground
Qal Recent Valley Fill
Qc Colluvium
Qt Terrace Alluvium
Qrf Rocky Flats Alluvium
Ka Arapahoe Formation, Claystone

SCALE: 1"=100'
CONTOUR INTERVAL = 2'

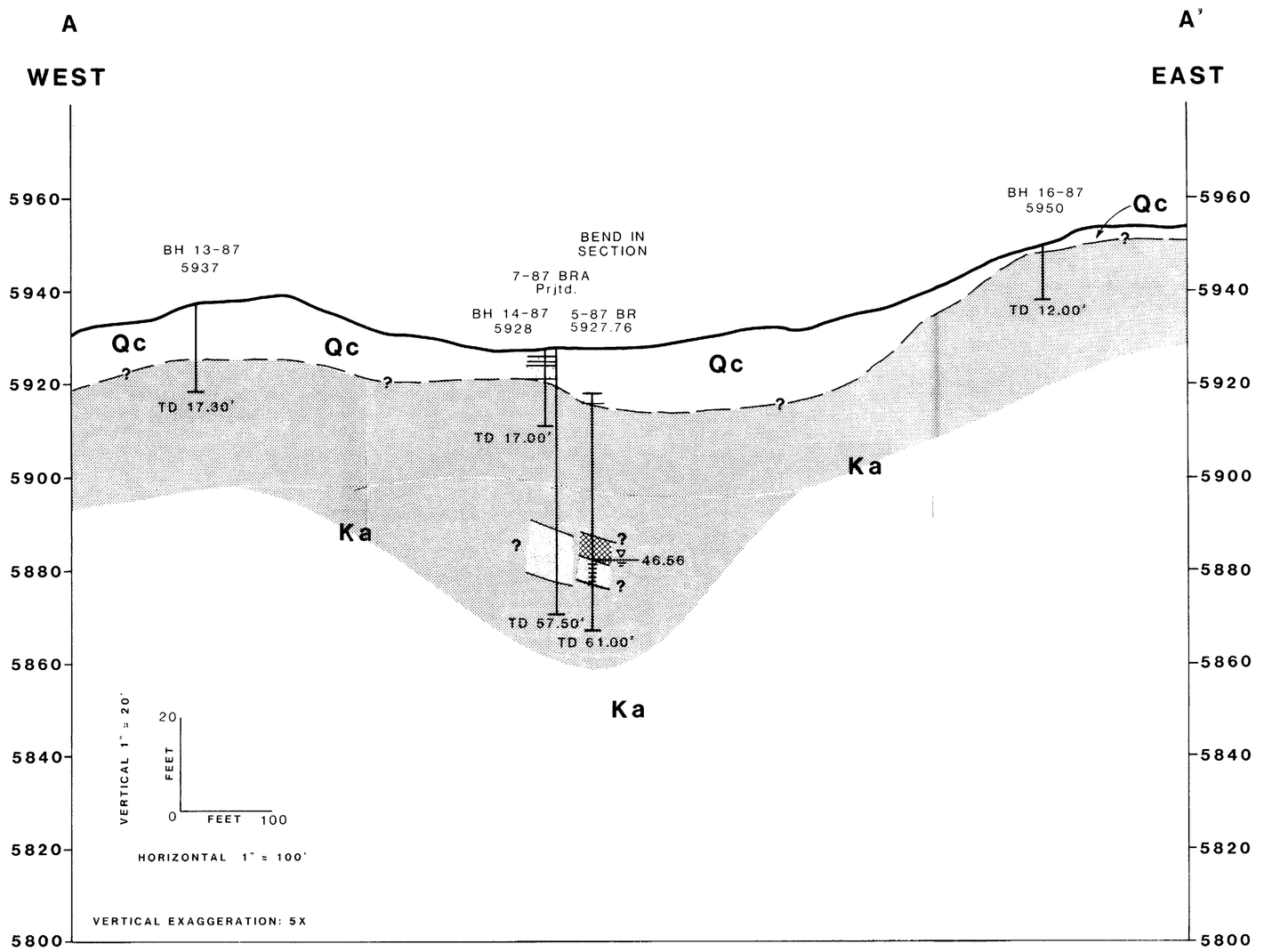
WESTON
215 Union Blvd.
Suite 600
Lakewood, Co. 80228
(303) 980-6800

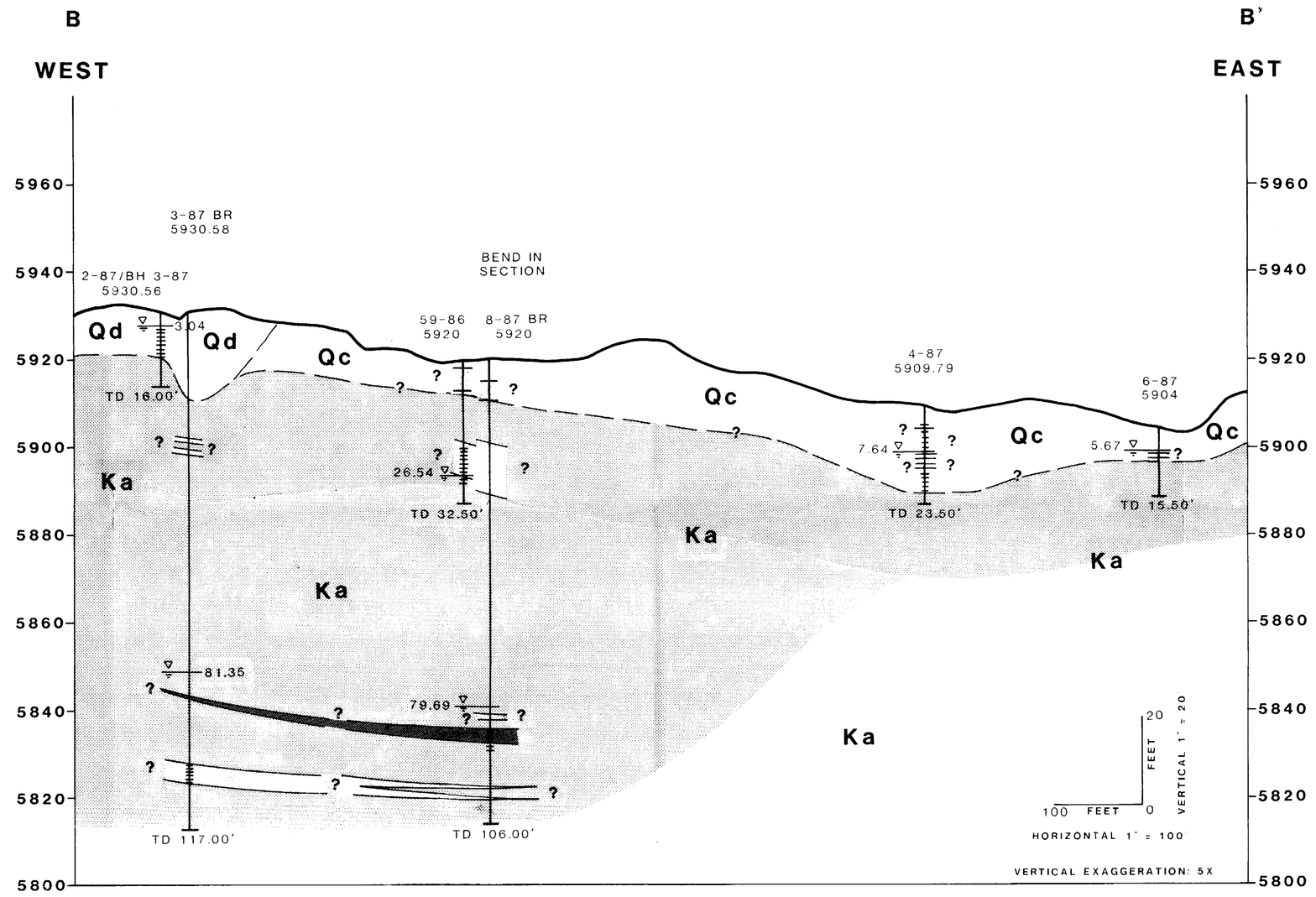
Rockwell International

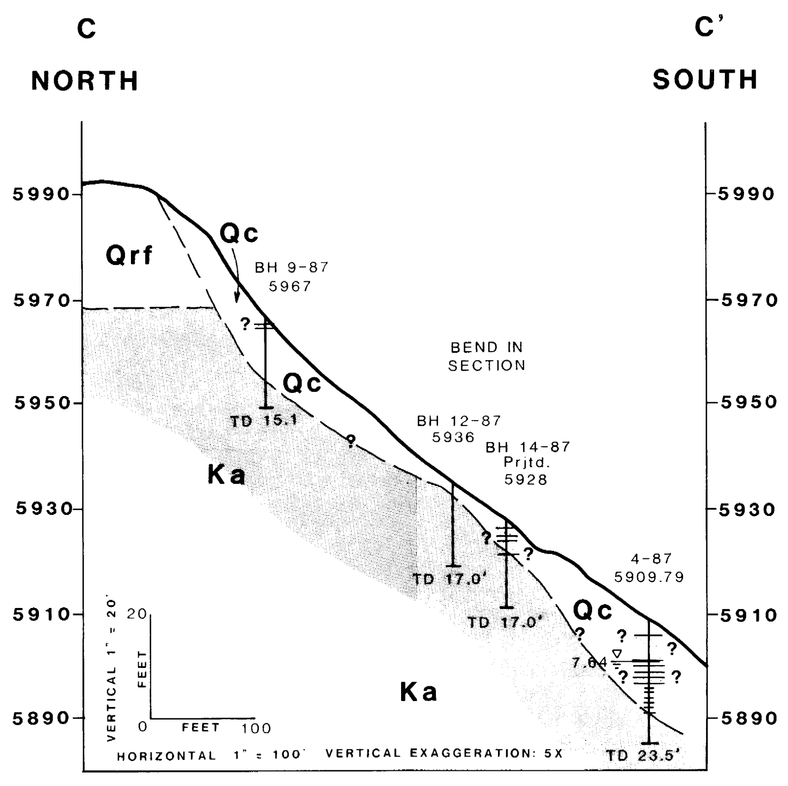
PLATE 4-2

GEOLOGIC MAP OF
881 HILLSIDE AREA

PREPARED BY J.B.B.
CHECKED BY S.S.P.
DATE PREPARED July 1, 1987







EXPLANATION

2-87/BH 3-87	WELL/BOREHOLE IDENTIFICATION
Prjtd.	PROJECTED
5930.56	GROUND SURFACE ELEVATION (SURVEYED)
	WATER LEVEL (MEASURED 6/24/87)
	GEOLOGIC CONTACT (DASHED WHERE INFERRED)
	SCREEN INTERVAL
TD 16.0'	TOTAL DEPTH DRILLED

QUATERNARY

- Qd DISTURBED GROUND
- Qc COLLUVIUM
- Qrf ROCKY FLATS ALLUVIUM

CRETACEOUS

- Ka ARAPAHOE FORMATION

- SAND AND GRAVEL
- SANDSTONE
- LIGNITE
- CLAYSTONE
- FRACTURES

NOTES:

GEOLOGY INFERRED BETWEEN DATA POINTS
SEE PLATE 4-1 FOR CROSS SECTION LOCATIONS
BASED ON DATA COLLECTED MAY-JUNE 1987
WATER LEVELS FROM DATA COLLECTED 6/24/87

WESTON MANAGERS ENGINEERS CONSULTANTS
215 Union Blvd.
Suite 600
Lakewood, CO. 80228
(303) 980-6800

ROCKWELL INTERNATIONAL

PLATE 4-3

881 HILLSIDE
CROSS SECTIONS
A-A' B-B', AND C-C'

PREPARED BY: K.D.H.
CHECKED BY: S.S.P.
DATE PREPARED: JULY 1, 1987

E 2083000
E 2083500
E 2084000
E 2084500
E 2085000
E 2085500
E 2086000
N 749000
N 748500
N 748000
N 747500
N36000
N 35500
N 35000
N 34500
E 23000
E 22500
E 22000
E 21500
E 21000
E 20500
E 20000

EXPLANATION

100 ■ Soil Gas Sampling Point

-N-

0 50 100 200
SCALE: 1" = 100'
CONTOUR INTERVAL = 2'

WESTON MANAGERS DESIGNERS CONSULTANTS

215 Union Blvd.
Suite 600
Lakewood, CO. 80228
(303) 980-6800

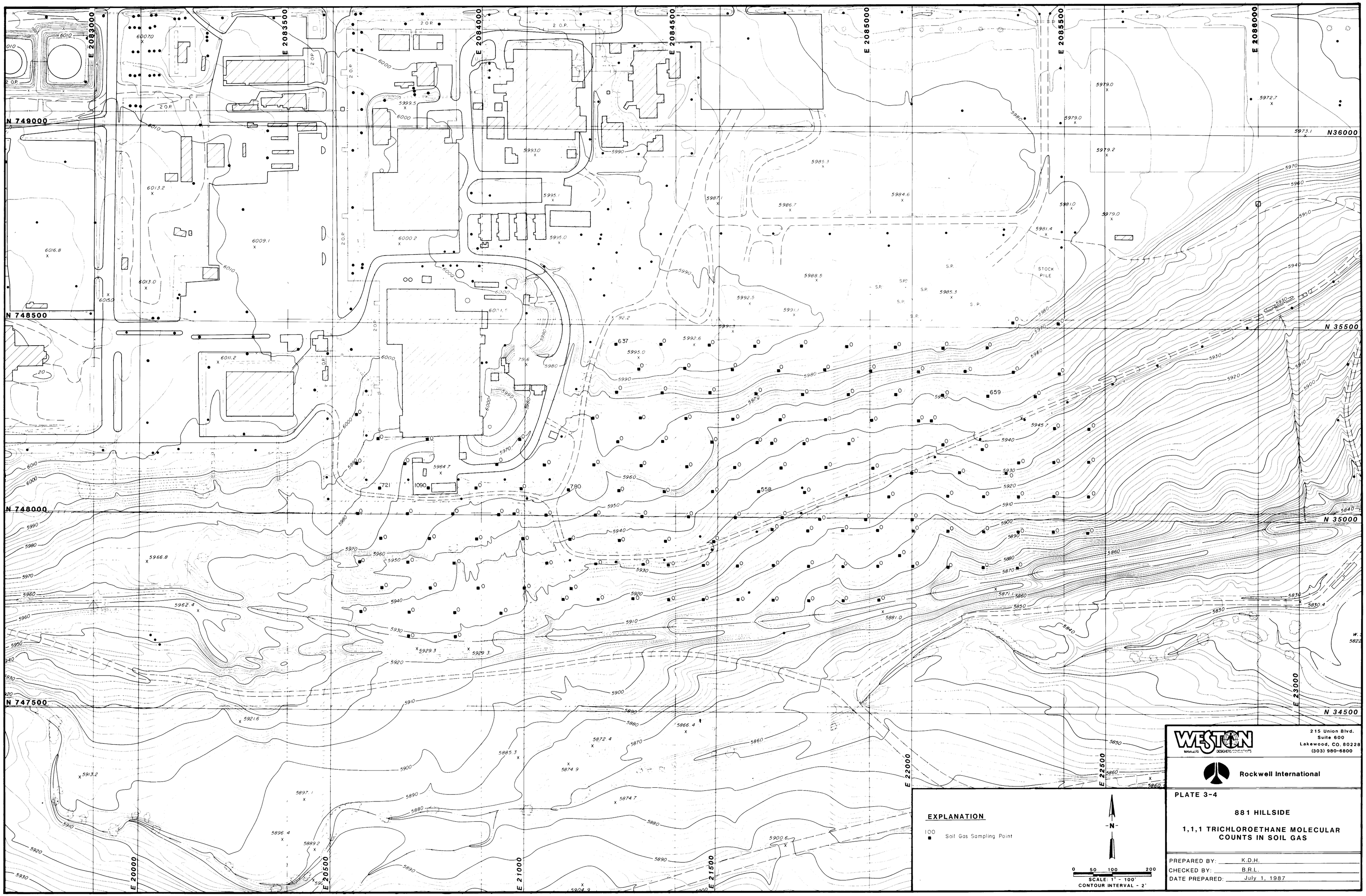
Rockwell International

PLATE 3-3

881 HILLSIDE

TETRACHLOROETHENE MOLECULAR COUNTS IN SOIL GAS

PREPARED BY: K.D.H.
CHECKED BY: B.R.L.
DATE PREPARED: July 1, 1987



EXPLANATION

100 ■ Soil Gas Sampling Point

-N-

0 50 100 200

SCALE: 1" - 100'

CONTOUR INTERVAL - 2'

WESTON MANAGERS DESIGNERS CONSULTANTS

215 Union Blvd.
Suite 600
Lakewood, CO. 80228
(303) 980-6800

Rockwell International

PLATE 3-4

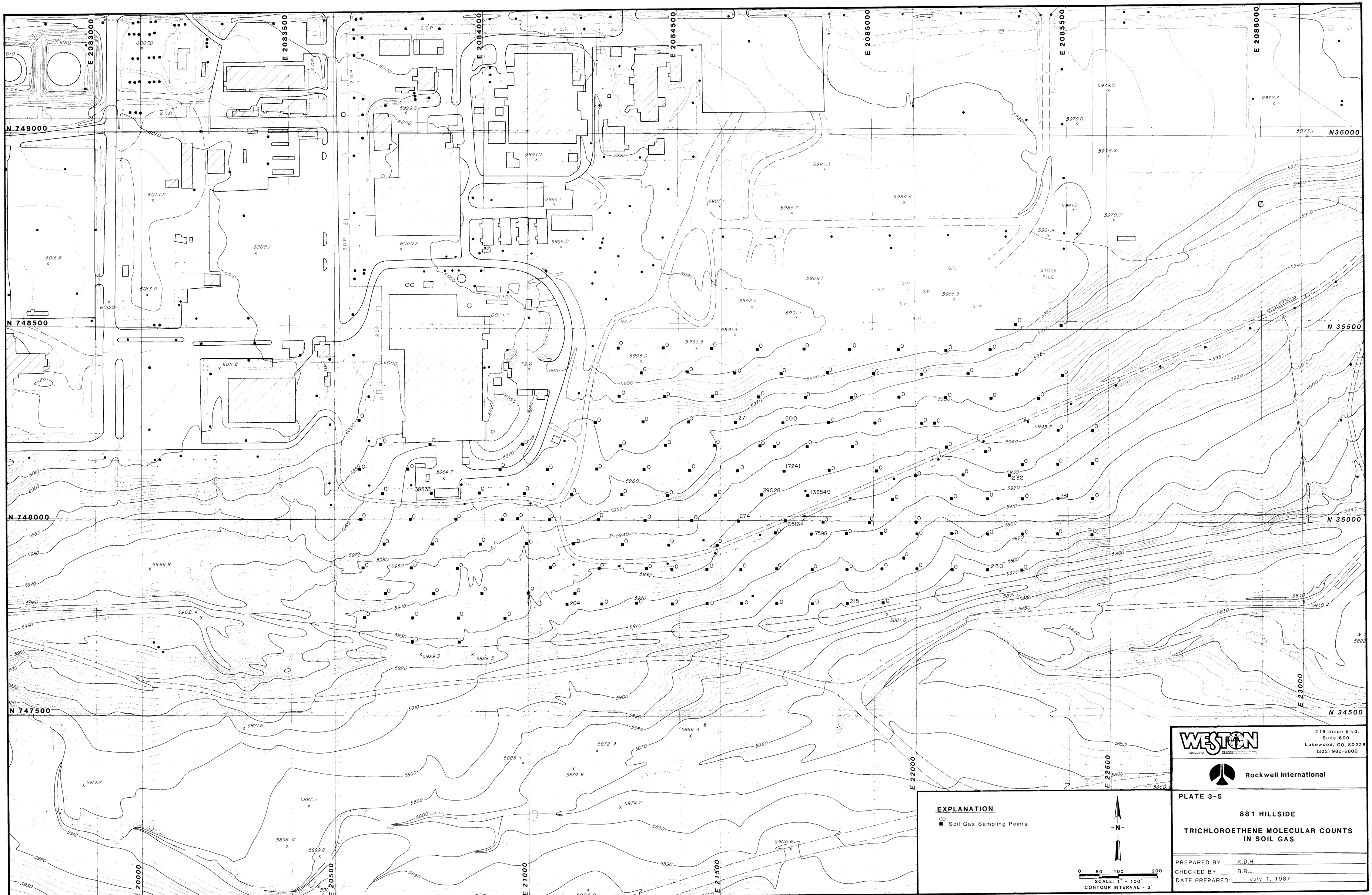
881 HILLSIDE

1,1,1 TRICHLOROETHANE MOLECULAR COUNTS IN SOIL GAS

PREPARED BY: K.D.H.

CHECKED BY: B.R.L.

DATE PREPARED: July 1, 1987



EXPLANATION

100
■ Soil Gas Sampling Points

N

0 50 100 200
SCALE: 1" = 100'
CONTOUR INTERVAL = 2'

WESTON DESIGNS

215 Union Blvd.
Suite 600
Lakewood, CO. 80228
(303) 980-6800

Rockwell International

PLATE 3-5

881 HILLSIDE

TRICHLOROETHENE MOLECULAR COUNTS IN SOIL GAS

PREPARED BY: K.D.H.
CHECKED BY B.R.L.
DATE PREPARED: July 1, 1987